VOLUME 2

Hydraulic Brakes

Cooling

Intake & Exhaust

Fuel System

Instrumentation

Body Electrical

Chassis Electrical

Steering

Body Structure

Seating / Restraints / Handrails

Body Finish

BLUE BIRD

ALL AMERICAN

A3FE

A3RE

2013

SERVICE MANUAL

COUNT ON BLUE BIRD

BLUE BIRD

10026187
Edition A

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The Blue Bird All American complies with all applicable federal and state regulations. These include, but are not limited to, Federal ADA as well as state accessibility, safety and security requirements.

The Blue Bird All American meets all applicable Federal Motor Vehicle Safety Standards (FMVSS) rules and regulations.

In the event of any conflict between the requirements of this publication and any applicable legal requirement, the legal requirement prevails. Technical requirements that exceed the legal requirements are not considered to conflict.

Many of the components of Blue Bird buses are obtained from outside suppliers. Where maintenance and/or service information conflicts with the component manufacturers documentation, the manufactures's documentation prevails.

Blue Bird Corporation continually endeavors to improve its product and reserves the right to change without notice. The material presented in this manual is accurate at the time of publication.

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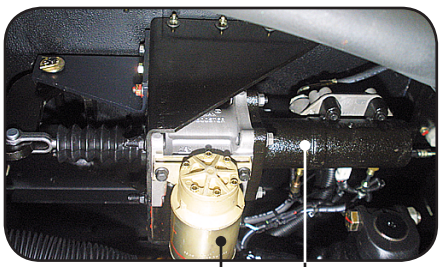
Overview

All American Forward Engine buses are available with hydraulic disc brakes. Hydraulic brakes are not offered on All American Rear Engine.

When hydraulic brakes are applied, two hydraulic systems come into play: The brake system, which is passive; and the power steering hydraulic system, which is pump driven. Although the two systems interact, they are separate closed circuits with separate fluid supplies. The component at which the two systems interact is the Bosch Hydro-Max™ master cylinder/booster assembly.



Under normal conditions with the engine running, the driver presses the brake pedal, acutating the master cylinder portion of the HydroMax which contains DOT 3 brake fluid which transfers pressure to the brake calipers on each wheel. The booster portion of the HydroMax receives hydraulic steering fluid and allows hydraulic pressure generated by the power steering pump to assist (boost) in actuating the master cylinder.

A pressure switch mounted on the body of the brake booster monitors pressure in the hydraulic power steering system. If pressure is absent when brakes are applied (as when the engine is not running), the pressure switch activates an electric pump mounted on the underside of the HydroMax to provide brake boosting power. The BRAKES warning light on the driver's instrument panel is also activated.

When there is no boost pressure in the HydroMax, and no boost is being provided by the electric pump (as when the ignition switch is off), the hydraulic brakes still operate, but require significantly greater pressure at the pedal.

The master cylinder, power boosted by the power steering pump system, transfers hydraulic pressure to the Antilock Brake System (ABS) modulator, mounted on a frame cross member located just aft of the transmission above the front end of the driveline. The modulator distributes the pressure in the brake system caliper assemblies mounted on each wheel, according to control signals it receives from the ABS Electronic Control Unit (ECU), which is mounted inside a compartment accessible through the Driver-side front access panel on the front of the bus.

At each wheel, a wheel speed sensor detects the speed of the rotating wheel and sends a signal to the ECU. The ECU monitors these wheel speed signals and controls the modulator to adjust the braking pressure at each wheel individually, so as to maintain traction (avoid wheel lock) at all wheels.

An All American Forward Engine bus equipped with hydraulic brakes may also be equipped with a brake interlock system, which actuates the brakes under certain conditions, such as a wheelchair lift door being open while the engine is running. The brake interlock system uses its own separate fluid supply, filled with DOT 5 fluid.

Blue Bird All American Forward Engine buses equipped with hydraulic brakes employ a cable-actuated drum-type parking brake installed on the rear of the transmission. The parking brake is not to be used as a normal service brake, but can be used to help stop the bus in an emergency situation.

Appendixes In This Chapter

Appendix 1: Hydro-Max Hydraulic Brake Booster and Master Cylinder. This Bosch publication details the operation of the master cylinder & booster assembly, and includes troubleshooting information.

Appendix 2: Hydaulic ABS. Meritor Wabco Maintenance Manual 39. Detailed information on the ABS Module and other ABS components. Includes troubleshooting using blink codes and Meritor Wabco Toolbox diagnostic software.

Appendix 3: Four Piston Quadraulic Disc Brake Caliper. Meritor MM-2075. Detailed information on disassembly, inspection, and reassembly of the brake calipers.

Maintenance Overview

Servicing the hydraulic brake system involves procedures at several levels.

- Regularly scheduled maintenance tasks such as inspection, fluid replenishment, and linkage lubrication. See the Hydraulic Brakes Maintenance chart below (also included in the Brakes chart in the Specs & Maintenance Chapter).

- Replace and/or service normal wear parts, such as brake pads and rotor surfaces, as they approach their service life specifications. These procedures must be performed according to the manufacturers' specifications. References are provided in the various component sections that follow.

- More involved overhaul or rebuild procedures for major components; for example, replacement of seals in the caliper(s). These also must be performed according to manufacturers' procedures. Appropriate references are provided in the respective component descriptions below.

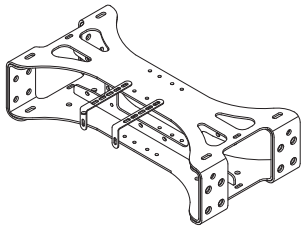
- When any part of the brake system's hydraulic fluid circuit is disassembled or loosened, the system must be bled before returning the bus to operation. This must be done according to procedure for the Meritor Wabco ABS system. See Hydraulic Brakes Appendix 2 (Meritor Wabco publication: Hydraulic ABS Maintenance Manual no. 39). Arvin Meritor also provides additional information online at www.arvinmeritor.com.

- Whenever servicing any part of the hydraulic brake system, remember that up to three different sub-systems may be involved, each with its own fluid circuit (steering & boost circuit, brake circuit, brake interlock circuit). Each of these ar closed circuits using different fluid types. The different fluid types must not be intermixed and must not be allowed to contaminate each other.

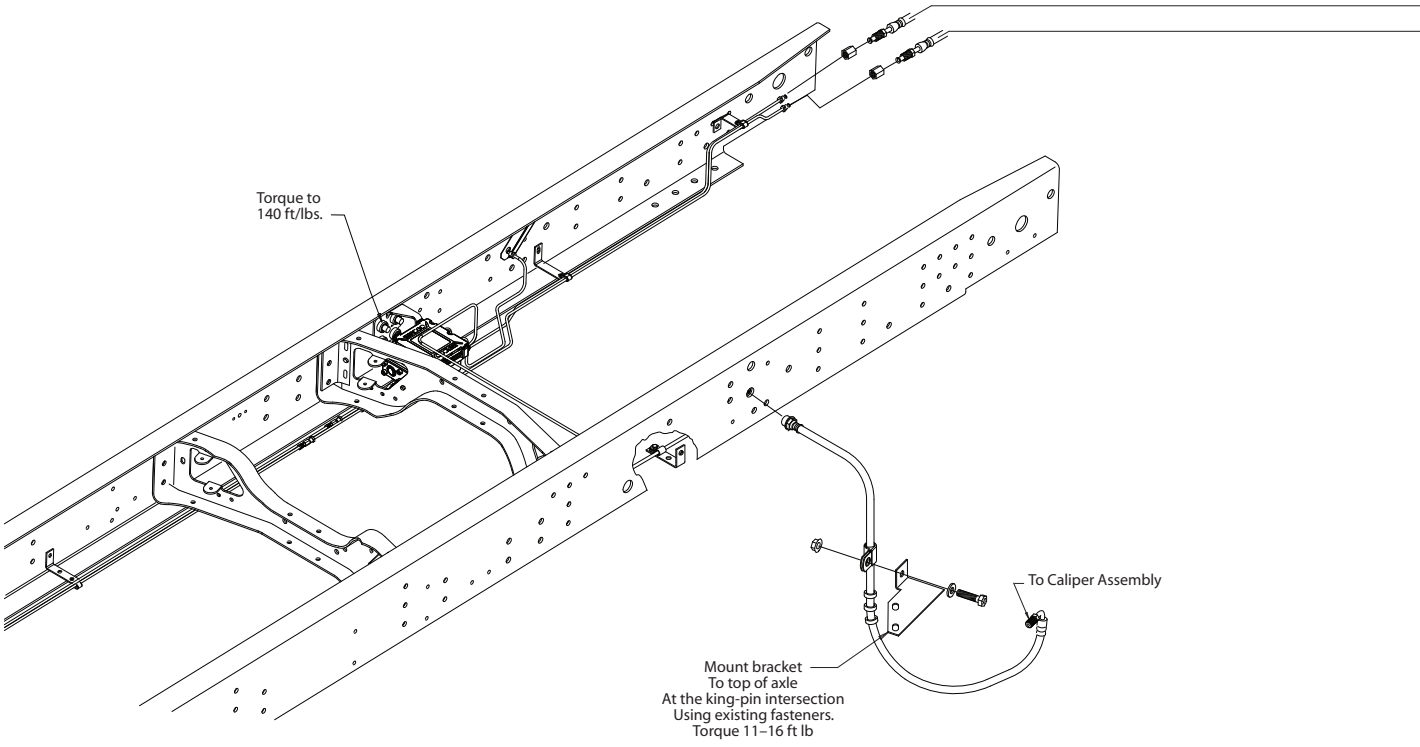
Hydraulic Brakes Maintenance

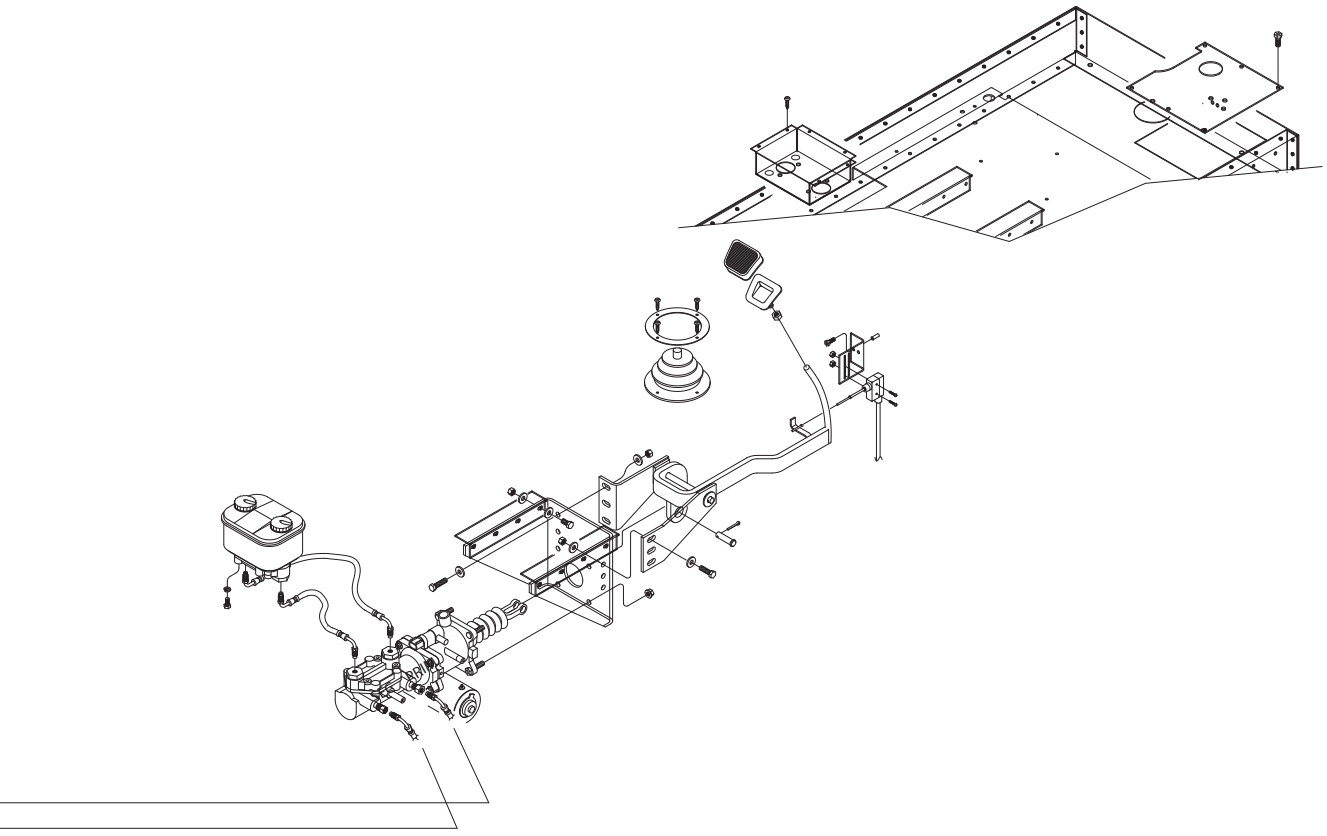
Interval: Months/1000 Miles
whichever occurs first

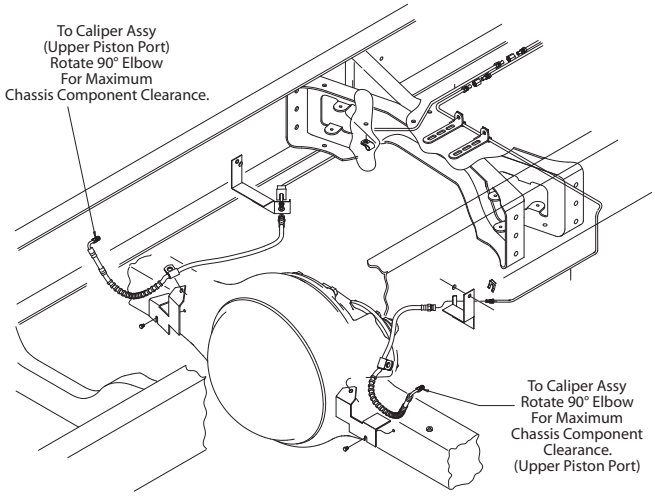
Operation	1 / 3,000	3 / 5,000	3 / 24,000	6 / 6,000	6 / 10,000	12 / 12,000	12 / 24,000	24 / 24,000	Notes
Hydraulic Brakes									
Check fluid level	•								*Use DOT-3 brake fluid.*
Inspect booster & master cylinder			•						*Inspect for signs of leakage or damage.*
Adjust park brake lever				•					*Adjust engagement pressure at the lever to 90-100 lbs.*
Hydraulic Brakes Interlock									
Check fluid level	•								*Use DOT-5 brake fluid.*
Hydraulic Brake Wheel Ends									
Inspect calipers				•					*Inspect for signs of leakage or damage.*
Lubricate calipers		•							*See Meritor documentation.*
Check pad thickness	weekly or as needed in severe applications								*Minimum ⅛ inch (3.175 mm).*



Bracket Placement
On Crossmember
With Hendrickson Air Suspension







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Hydraulic Brake System

Brake Light Switch Mounting & Adjustment

1. Install brake light switch (item 5) to hydraulic brake switch bracket on driver's platform.

2. Pull down on brake lever assembly with just enough pressure to remove clearances in clevis pin, bearing, and brake booster yoke.

3. Move the switch/bracket assembly vertically within the slots of the bracket until the contacts close. Lower the assembly an additional 1/8 inch.

4. Tighten switch mounting fasteners.

5. Check to make sure switch contacts are open with brake lever assembly released.

Master Cylinder

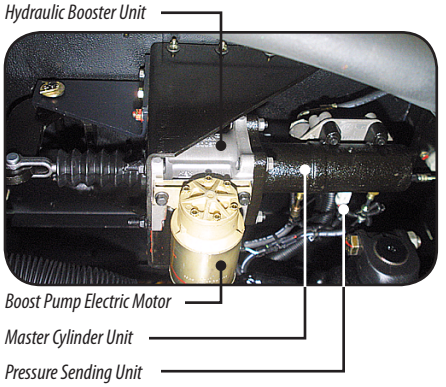
The master cylinder is mounted directly to the body of the hydraulic booster. These two components are mounted as a unit to the underside of the chassis front assembly, directly below the Driver area floor.

The fluid reservoir for the brake system is mounted in a compartment on the floor behind the Driver's seat, and is accessible from inside the bus. The reservoir contains DOT 3 brake fluid.

When the brake is operated, pistons in the master cylinder drive brake fluid that it receives from the reservoir into the brake lines, transferring the mechanical force to the brake calipers at each wheel.

The master cylinder is internally divided into two hydraulic circuits; one for the front brakes, and one for the rear. The fluid reservoir is similarly divided, thus its two fill caps. Hydraulic leakage or complete failure in one system does not affect function of the other system.

An electric sending unit is mounted to the side of the master cylinder. If significant pressure difference is detected between the front and rear brake circuits, the sensor sounds a warning buzzer in the driver's area and turns on the BRAKES light on the instrument panel.



Troubleshooting

Symptoms that may indicate master cylinder failure include, but are not limited to:

- Brake fluid leakage from between the master cylinder and booster.
- Hard pedal. Excessive pressure is required at the pedal to apply brakes.
- Excessive pedal travel. Pedal goes to the floor.
- Actuated pedal does not return.
- Brake drag.

For a more detailed description the master cylinder's operation, as well as trouble-shooting guidelines, see Hydraulic Brakes Appendix 1 (Bosch publication: HydroMax Hydraulic Brake Booster and Master Cylinder). If the master cylinder is determined to be malfunctioning, it must be replaced. Replacements are available from your Blue Bird Parts Dealer.

Removal

The master cylinder may be unbolted from the booster without removing the entire master cylinder/booster combination as a unit. However, it is possible that when the master cylinder is unbolted from the booster, the booster's internal spring may cause its o-ring seal to pop out, spilling hydraulic fluid. Thus, it is a good practice to take measures to catch the hydraulic fluid in case this occurs.

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. Disconnect the harness wire from the master cylinder's balance sending unit.

4. Position a suitable container under the master cylinder/booster assembly.

5. Disconnect the two hydraulic lines from the master cylinder.

6 Remove the four bolts and nuts which fasten the master cylinder to the booster and remove the master cylinder.

Reinstallation

Install the master cylinder by reversing the removal procedure.

1. Mount the master cylinder to the booster and tighten the four bolts to 25–30 ft. lbs. (33.9–40.7 Nm).

2. Reattach the brake fluid lines and tighten the nuts to 200 in. lbs. (22.5 Nm).

3. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Brakes Appendix 2 (Meritor Wabco publication: Hydraulic ABS Maintenance Manual no. 39).

Booster

The brake booster is the portion of the HydroMax unit which is mounted directly to the support bracket under the Chassis front assembly. The booster itself serves as the support for the brake master cylinder.

During normal operation, fluid pumped by the hydraulic pump flows through the booster's inlet, throttle valve, and power piston, and then exits through the outlet port. When the brake pedal is applied, the booster's input rod activates the throttle valve, restricting flow through the power piston. The resulting pressure, acting upon the power piston, applies force to the master cylinder's primary piston, "boosting" the force applied to it by the driver.

Within the HydroMax assembly, the steering fluid which powers the booster is isolated from the DOT 3 brake fluid which acts upon the master cylinder.

The Booster assembly incorporates an electric motor/pump which provides braking boost whenever hydraulic flow ceases in the booster. A flow switch mounted at the top of the booster, next to the outlet port is held open by the normal flow of hydraulic fluid into the outlet. When pressure is absent, this switch closes, energizing a power relay, and thereby providing electrical power to the motor. The switch also causes a buzzer to sound in the driver's area and the BRAKES warning light to illuminate in the instrument panel.

Troubleshooting

Symptoms which may indicate booster failure include, but are not limited to:

- Hydraulic steering fluid leakage between the master cylinder and booster.
- Hard pedal. Excessive pressure is required at the pedal to apply brakes.
- Actuated pedal does not return.
- Brake self apply May indicate self applied booster due to too high fluid flow.
- Brake drag. May indicate selfapplied booster due to too high fluid flow

For a more detailed description the booster's internal operation, as well as troubleshooting guidelines, see Hydraulic Brakes Appendix 1 (Bosch publication: HydroMax Hydraulic Brake Booster and Master Cylinder). If the booster is determined to be malfunctioning, it must be replaced. Replacements are available from your Blue Bird Parts Dealer.

Removal

As described above, the booster supports the master cylinder. Although it is possible to remove the booster without removing the master cylinder, doing so will require devising means by which to support the weight of the master cylinder so as to avoid bending the brake lines. The following procedure therefore assumes that the master cylinder/brake booster assembly will be removed as a unit, and that the two components will be separated after removal. Note that this will require that the brake system be bled after reassembly.

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. The brake balance sensor and the booster pressure sensor lead to a single connector at the wire harness. Disconnect the connector. Disconnect the boost pump motor relay.

CAUTION ***Do not apply the brakes after removal of the input hose unless the reserve boost system is disconnected. Reserve boost pressure will blow the inlet check valve out of the booster.***

4. Loosen the hose clamp at the booster outlet, remove the hose and plug its end.

5. Remove the hose fitting at the booster inlet and plug its end, and/or support it vertically to prevent spillage.

6. Disconnect both output brake lines from the master cylinder.

7. Disconnect and plug the reservoir fluid lines which lead to / from the master cylinder.

8. Remove the cotter pin, washer and clevis pin which connect the booster push rod to the brake pedal lever.

9 Remove the four nuts which secure the booster's mounting studs to the mounting bracket. While doing this, have a helper support the master cylinder/booster assembly, or devise other means to support it while removing the nuts.

10. With the HydroMax assembly removed from the bus, remove the four bolts, nuts, and washers which fasten the master cylinder unit to the booster unit.

Servicing

If found defective, the brake booster must be replaced. Contact your Blue Bird parts dealer for a replacement. Refer to Appendix 1 for more information.

Installation

Install the booster by reversing the removal procedure.

1. Assemble the master cylinder to the booster and tighten the four bolts to 25–30 ft. lbs. (33.9–40.7 Nm).

2. Mount the reassembled master cylinder/booster unit on the vehicle and tighten the four mounting nuts to 18–25 ft. lbs. (24.4–33.9 Nm).

3. Reattach the brake fluid lines to the master cylinder and tighten the nuts to 200 in. lbs. (22.5 Nm).

4. Reattach the brake fluid reservoir lines to the master cylinder and tighten.

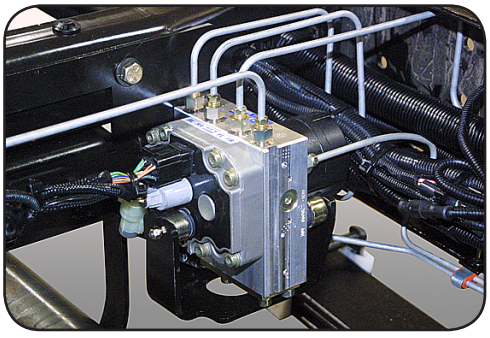
5. Attach the booster push rod to the brake pedal lever with the clevis pin and washer. Use a new cotter pin.

6. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Appendix 2.

ABS Modulator

The ABS modulator is mounted in a bracket affixed to a frame crossmember, just above the forward end of the front most driveshaft. The modulator houses the ABS solenoid control valves (one inlet valve and one outlet valve per wheel), a pump motor, and two accumulators

Under normal braking conditions, the modulator unit receives brake fluid pressure from its two inlets (one for the front brakes; one for the rear) and distributes it evenly to the brake calipers. However, if a one-quarter turn of the wheels is detected, the ABS Electronic Control Unit cause a solenoid control valve to regulate the brake pressure. During such an ABS stop, the solenoid valve is rapidly pulsed; opening and closing up to 40 times per second to control the brake pressure and prevent wheel lock. When this occurs, the driver may notice a pulsation of the brake pedal.



ABS Modulator

Troubleshooting

For troubleshooting and diagnosis of the modulator, see Appendix 2. The modulator should be replaced as a unit if found to be defective.

Removal

Removing the modulator involves three electrical plugs, six brake fluid tubes, and three mounting studs:

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. Disconnect the chassis wire harness's control plug and main ground plug from the modulator unit. Disconnect the pump's pigtail connector from the chassis wire harness.

4. Mark the six brake lines for ease of installation. Place a container under the modulator assembly to catch leaking brake fluid. Disconnect the six brake lines.

5 The mounting holes of the bracket are slotted and open on the top. Loosen the mounting nuts on the modulator's three rubber isolator mounts remove the modulator.

Reinstallation

Reinstall the modulator in the reverse order of removal, being sure to tighten fittings to the appropriate torque values:

1. Place the modulator in its bracket, being sure the studs of the three rubber isolators seat in the bottom of the mounting slots. Tighten the mounting stud nuts to 132 in. lbs (15 Nm).

2. Connect the main ground plug and the control plug on the chassis wire harness to the unit. Connect the pump's pigtail connector into the wire harness.

3. Connect the two small brake lines and tighten to 108 in. lbs. (12 Nm).

4. Connect the four larger brake lines and tighten to 132 in. lbs. (15 Nm.).

5. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Brakes Appendix 2 (Meritor Hydraulic ABS Maintenance Manual no. 39) for brake bleeding procedure.

Wheel Speed Sensors

A wheel speed sensor is mounted on the inboard side of each wheel assembly. As the wheel rotates, the flats of a notched casting in the wheel end assembly pass in close proximity to the sensor. The sensor responds to the passing notches magnetically and outputs a voltage, which increases with the speed of the wheel. This signal is then used by the ABS ECU to determine when wheel lock is immanent. All four wheel speed sensors are the same model, 90-degree Meritor Wabco WS-24.

Troubleshooting

Appendix 2 includes specific information on testing the output voltage and resistance of the wheel speed sensors. Sensors found out of range should be replaced.

Removal

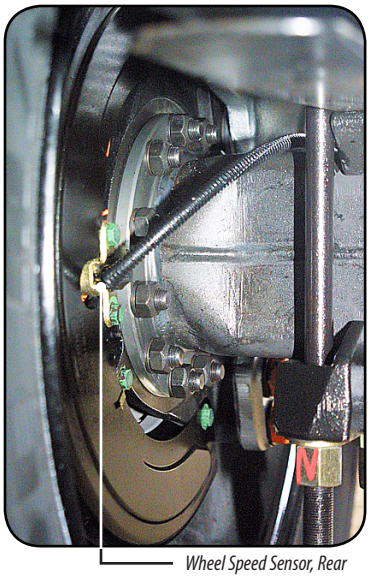
The sensors are held in place by the friction fit of spring clip sleeves which are inserted into the mounting blocks with the sensors. To remove a sensor:

1. Apply the parking brake. Chock the tires to prevent vehicle movement.

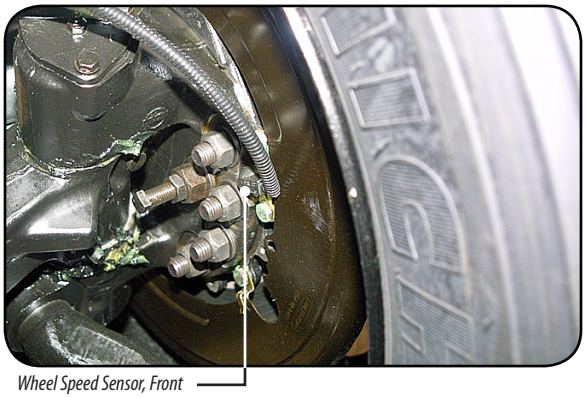
2. Disconnect the sensor cable from the wire harness and remove the cable from any cable clamps or clips.

3. Pull the sensor straight out of its socket, using a twisting motion if required. Do not pull on the wires. On front wheels, removal of the sensor may be impeded by interference with the steering arm casting. If this occurs, removal may be more easily achieved by removing the two bolts which secure the sensor's mounting block.

4. The spring clip may remain in the socket, or may pull out with the sensor. Remove and inspect the spring clip. Replace any damaged spring clips with new ones.



Wheel Speed Sensor, Rear



Wheel Speed Sensor, Front

Installation

The steps below assume the sensor has been removed without removing its mounting block. If removal of the sensor has required removal of its mounting block, install the new sensor into the mounting block according to the steps below and reinstall the mounting block using a thread locking compound on the threads of the two bolts and tighten the two mounting bolts to 16–18 ft. lbs. (21.7–24.4 Nm).

1. Connect the new sensor cable to the chassis harness.

2. Press the sensor spring clip into the socket until it stops. Make sure the tabs are on the inboard side.

3. Apply an appropriate lubricant to the shank of the sensor. Lube must be mineral oilbased and contain molydisulfide. It should have excellent anticorrosion and adhesion characteristics and be capable of continuous function in a temperature range of 40° to 300°F (40 to 150° C).

4. Push the sensor completely into the spring clip until it contacts the exciter ring.

5. Reattach the sensor cable to the cable clamps or clips.

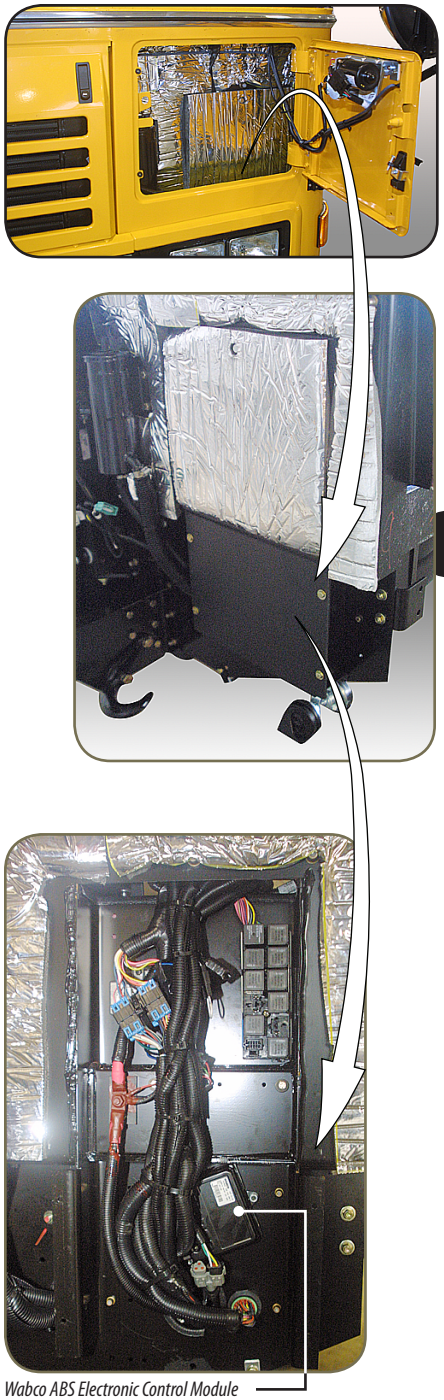
6. Secure the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable.

ABS Electronic Control Unit (ECU)

The ABS System ECU is the "computer" which monitors and controls the other components of the ABS System. The unit receives signals from the wheel speed sensors, processes them, and generates solenoid valve commands for the ABS modulator to reduce, maintain, or reapply brake pressure.

When the ECU senses an error in the system, it activates the ABS light on the driver's instrument panel according to a set of blink codes, which can help diagnose the system. A description of the blink codes is contained in Appendix 2

The ECU also stores ABS errors which it has detected but which are not presently active. This information can be accessed and used to troubleshoot the ABS system using Meritor Wabco's PC-based diagnostic software. The PC is connected using an appropriate adapter to the 9-pin diagnostic port located in the lower left corner of the Driver's leg area. Once connected, the diagnostic software can communicate with the ECU to display system faults and wheel speed data, test individual components, verify wiring, and more. The specific interface adapter needed varies according to the specific computer setup being used. Meritor Wabco provides a toll-free number, 800/535-5560, for ordering the software and for assistance.



Wabco ABS Electronic Control Module

Removal

On All American Forward Engine buses with hydraulic brakes, the ECU is mounted inside a boxed compartment just below the circuit breaker box which is located inside the Driver side front access panel. The compartment is covered by a metal panel which is secured by four bolts. To remove:

1. Park the bus on a level surface with parking brake on. Disconnect the negative terminal of the battery.

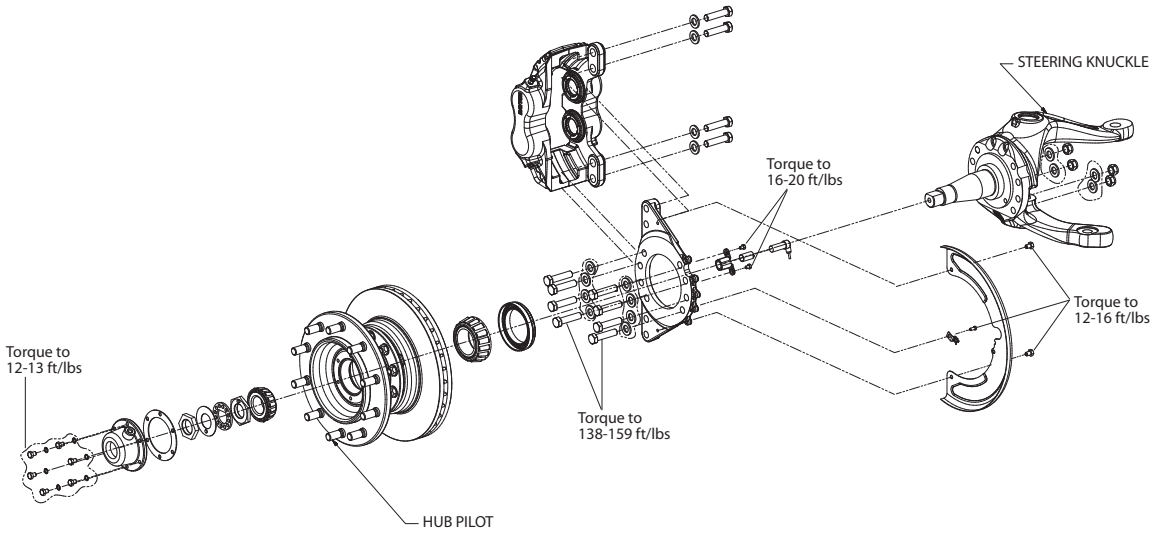
2. Open the Driver side front access panel. Locate the electrical panel door covered with insulation material slightly toward the right of the opening. The compartment which houses the ECU is immediately below that electrical panel, immediately behind the headlight housing. Four through-bolts with nuts and lock washers secure a cover plate to flanges of the compartment. These bolts can be accessed through the front access panel opening and/or from below the bus, looking upward from behind the front bumper. Remove the four bolts, nuts, and washers and lower the cover plate.

3. Locate the ECU in the compartment. Disconnect the three harness wiring plugs from the bottom side of the ECU.

4. Remove the three hex-head bolts which mount the ECU to the back wall of the compartment.

Installation

Reinstall the ECU in reverse order of the removal steps.



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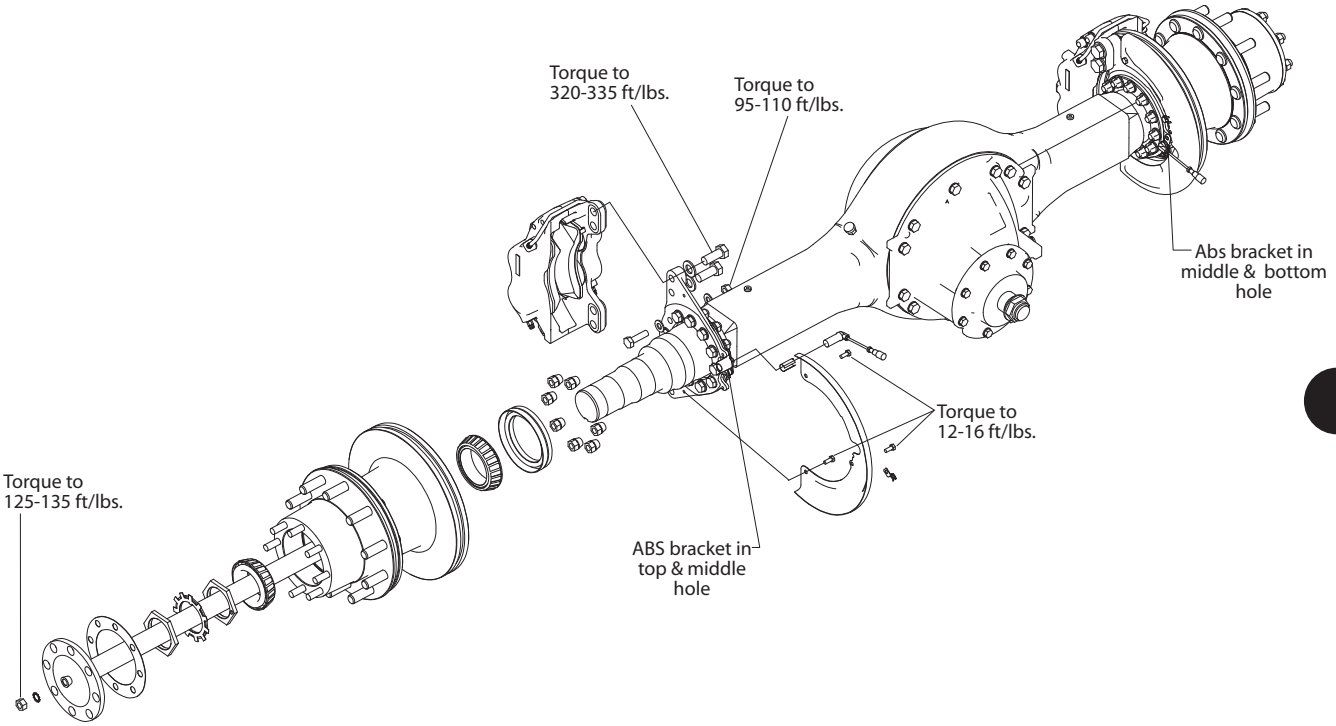
Hydraulic Brakes Wheel Ends, Front



0098981E

Hydraulic Brakes Wheel Ends, Rear

Calipers

The Blue Bird All American with hydraulic brakes uses Meritor 70mm four piston Quadraulic disc brake calipers. The same model caliper is used on all four wheels, but left and right side housings are mirror versions. An installation includes four major components: the caliper itself, the caliper support assembly, hub/rotor assembly, and attaching hardware.

When brakes are applied, brake fluid pressure (as regulated by the ABS modulator) causes the caliper's pistons to extend, pressing the brake friction pads against the surfaces of the rotor. The brake fluid line from the modulator attaches directly to the inboard side of the caliper. A crossover tube supplies fluid to the outboard pistons.

Servicing

If a caliper assembly is leaking, has stuck piston(s), or is otherwise found damaged, it must be replaced or rebuilt according to manufacturer's instructions. Step by step procedures for rebuilding the brake calipers are included in Appendix 3.

WARNING ***Do not rebuild a caliper with damaged piston bore(s). If the piston bore is corroded, galled or scratched, replace the caliper assembly. Replacing only the piston and seals will not correct the damage. Do not attempt to hone or rebore damaged piston bores. Piston sized for honed caliper bores are not available.***

Removal

The caliper housing is mounted to the caliper support assembly by four bolts on the inboard side of the caliper.

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.
2. Raise the wheel to be serviced and support the vehicle with safety stands.
3. Remove the tire and wheel assembly.
4. Remove the brake hose from the inboard side of the caliper.
5. Remove the four calipertosupport assembly bolts.

Installation

To install the caliper, reverse the removal process. Torque the caliper mounting bolts to 320–360 ft lb (434–488 Nm). Bleed the affected brake lines system and road test the vehicle before returning it to normal service.

Brake Pads

The brake pads on the front and rear of the All American, and on the inside and outside of the calipers are identical (8 total). Whenever working on the brake system, avoid contamination of the brake pads by brake fluid or grease. Contaminated brake pads, even if new, must be replaced.

Inspection

Brake pads should be inspected for amount of wear at least every 3000 miles. When the friction pad material is worn to a thickness of 1/8 inch (3.2mm), the pads must be replaced. It is recommended that when one brake pad has reached its service limit, all brake pads should be replaced. If not, at least the brake pads on both sides of the same axle must be replaced at the same time.

Removal

Removal of the brake pads requires removal of the wheel, but not of the caliper. The brake pads are held in place by retainer spring plates, which are secured with one bolt.

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving. Raise the wheel to be serviced and support the vehicle with safety stands.

2. Remove the tire and wheel assembly.

3. Remove the master cylinder reservoir filler cap. Check the brake fluid level in the reservoir. If necessary, remove fluid to keep the reservoir from overflowing when the caliper pistons are compressed.

4. Remove the pad retainer spring bolt and remove the retainer spring. Remove the two brake pads.

Installation

Because the pistons travel out from their bore during the wear of the pads, it is necessary to compress them back into their bores sufficiently to accommodate the thickness of the new pads.

1. Compress the caliper pistons. This can be done with a thin plate and C clamps as shown. Compress the two pistons slowly and equally so as to avoid cocking or wedging either piston in its bore.

2. When the pistons have been retracted enough to accommodate the new pad, insert the new pad. Be sure that the friction side is against the rotor.

3. Insert the tab of the retainer spring into its retaining hole on the outboard side of the caliper. Install the retainer spring bolt and tighten to 30 ft lb.

Brake Rotors

Disc brake rotors are subject to temperature and stress extremes. As brake pads wear during normal operation, grooves or ridges may develop in the rotor surfaces as a result of road contaminants. The service life of the rotor surfaces may or may not correspond to that of the pads, depending upon operating conditions.

The front axle on the Blue Bird All American with standard hydraulic brakes is a Hendrickson 60952 axle with Meritor brake components. The rear axle is a Meritor RS 21145NFB1012 with Meritor brake components. Removal procedures differ accordingly.

Inspection

Whenever replacing brake pads, inspect the rotors for scoring, warping, cracks, bluing, heat spots or other damage, and for minimum thickness. Repair or replace if necessary. Rotors may be resurfaced at an appropriate truck brake service shop. The thickness of the resurfaced rotor must always exceed the minimum thickness dimension stamped or cast into the rotor. Replace if necessary.

Check the rotor while it is assembled to the hub and mounted on the axle. The lateral runout of the rotor friction surfaces should not exceed .015 in. (.381 mm) total indicator reading (TIR). The thickness variation of the rotor should not exceed .0012 in. (.03 mm). If the lateral runout and/or the thickness variation exceed these values have the rotor resurfaced.

Brake Rotor Removal

Remove the front rotor as follows:

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.
2. Raise the wheel to be serviced and support the vehicle with safety stands.
3. Remove the tire and wheel assembly.
4. Remove the brake caliper assembly as described in the Calipers section.
5. Remove the ABS sensor.
6. Remove the drain plug from the oil lube hubcap. Drain the oil
7. Remove the six bolts which fasten the hubcap. Remove the hubcap and its gasket.
8. Flatten the tab of the bendable lock washer to allow removal of the wheel nut. Remove wheel nut and bendable lock washer.
9. Remove the pierced lock ring.
10. Remove the adjusting nut.

11. Remove the outer tapered cage bearing.

12. Slide the hub/rotor assembly off the axle. Note that the inner bearing and seal will slide off together with the hub. Take care to maintain alignment so as to avoid damaging the seal.

Front Brake Reassembly

1. Clean mating surfaces of both the axle brake flange and the hydraulic brake torque plates.

2. Install the ABS bracket (supplied with brake) onto the torque plate.

3. Install the dust shield (if equipped) onto the torque plate.

4. Install torque plates on brake mounting flange using specified hardware. Torque plates are right and left handed and must be installed on the correct side. Torque plates are to be installed with the caliper mounting surfaces toward the rear and outside of the chassis. Torque mounting hardware in a crossing sequence.

Wheel Bearing Lubrication

Wheel bearings are precision components which must be kept clean and adequately but not excessively lubricated.

1. Lay out bearings to be used on a clean area.

2. Dip clean bearings in the appropriate sae 50 gear oil until thoroughly saturated.

Inner Bearing And Seal

1. Seat smaller O.D. Of seal in recess of tool.

2. Insert centering plug of tool in bore of inner bearing. Plug insures proper alignment of seal.

3. Insert tool with bearing and seal in the vehcile center end of hub and rotor assembly.

4. Hold tool and handle firmly and strike until sound of impact changes to indicate seal has bottomed in hub seal recess.

5. After seal is bottomed in the bore recess, inspect the face of seal for dents or deformity and check the rubber lip for a smooth even surface. Check for freedom of movement by manually moving interior rubber componts of seal back and forward. A slight movement indicates damage free installation.

Hub And Rotor Assembly

1. Clean spindles before installing wheel end components.
2. Clean the threads on the spindles with a wire brush.
3. Coat the lip of the rubber seal with a thin layer of wheel bearing lubricant.
4. Carefully slide the hub and rotor assembly straight onto the spindle to prevent damage to the seal.
5. Install the outer wheel bearing. Make sure bearing is properly lubricated.
6. After the hub and bearings are assembled in place on the spindle, install the bearing adjusting nut on the spindle against the outer bearing. The nut must be installed so that the nipple faces outward toward the hubcap. Tighten finger tight.
7. Torque the bearing adjusting nut to 200 ft lb while rotating the hub to seat the bearings. Back off the adjusting nut 1/2 turn. Re-torque nut to 50 ft lb while rotating hub back and forth. Back off nut 1/4 turn.
8. Install the pierced lock ring so that the inner tab locks into the spindle keyway and the adjusting nut nipple engages the through holes on the lock ring. Nut may be loosened slightly to install lock.
9. Install the lock washer onto the spindle so that the nipple engages one of the through holes on the lock ring.
10. Install the outer nut. Tighten to 240-260 ft lb. Rotate wheel in both directions. Wheel must rotate freely without binding.
11. Bend two opposed lock washer tabs over the outer wheel nut to lock it in position.
12. Install the axle flange gasket.
13. Install hubcap.
14. Remove plug in hub cap and fill with proper oil. Use the sight glass indicator to fill to proper level. Do not overfill!
15. Install brake calipers.

ABS Sensor Installation

1. Firmly install the abs sensor clip in the mounting bracket on the torque plate. The clip is designed to seat in the proper position in the clip.

2. Snap the ABS sensor into the clip just installed. The clip is designed to hold the sensor with a pressure fit.

3. Push the ABS sensor all the way in until it stops against the tone ring. The sensor is self gapping.

4. Route the wire from the wheel area to brake ECU Tie wrap the cable to the brake flanges or axle housing.

Rear Brake Removal,

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.

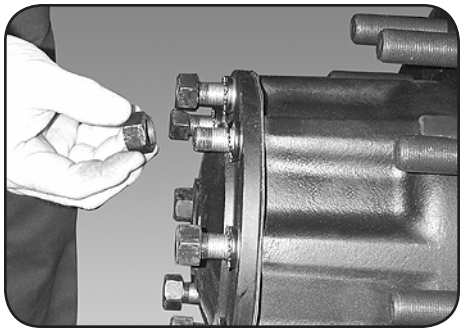
2. Raise the wheel to be serviced and support the vehicle with safety stands under the frame rails.

3. Remove the tire and wheel assembly.

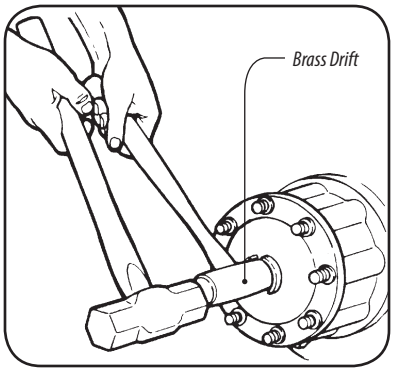
4. Remove the brake caliper assembly as described in the Calipers section.

5. Place a drain pan under the end of the axle to catch brake axle lubricant.

6. Remove the 8 axle nuts and 8 star lock washers.



7. The axle end cap is centered by conical dowels on each of the 8 studs. It may be necessary to loosen the dowels, to allow removal. Hold a 11/2" diameter brass drift against the center of the axle end cap, inside the round driving lugs. Then strike the end of the drift with a large hammer (56 lbs.). Remove the loosened dowels.

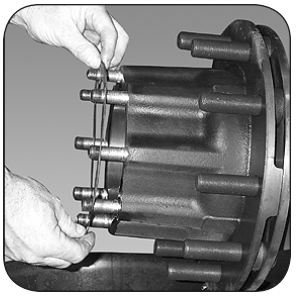


8. Remove the axle shaft and gasket.

9. Inside the rotor hub, the outer 4" adjusting nut is held in place by a tabbed retainer washer. Using a small hammer and punch, straighten the bent tabs of the lock washer.

10. Remove the outer 4" adjusting nut, the tabbed washer, and the wheel bearing lock washer.

11. Remove the 4" adjusting nut and the outer wheel bearing.



The rotor can now be removed. Remove the rotor gently and as straightly as possible to avoid damage to the inner bearing rubber seal and ABS sensor.

ABS Sensor Installation

Inspect the ABS wheel sensor and replace if damage is found.

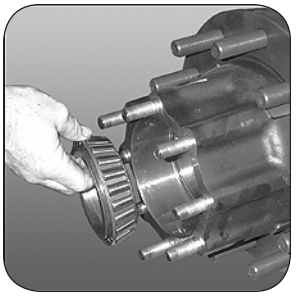
1. Firmly install the abs sensor clip in the mounting block on the spindle. The clip is designed to seat in the proper position in the clip.

2. Push the ABS sensor into the clip just installed. The clip is designed to hold the sensor in position.

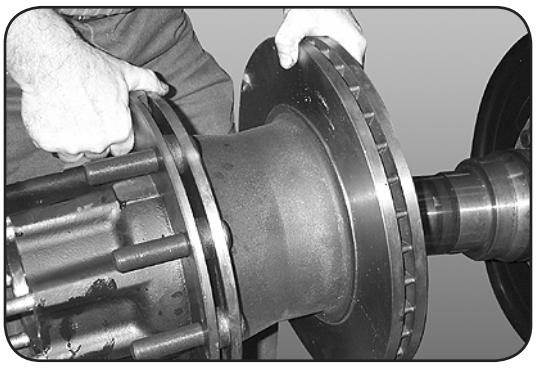
3. Push the sensor all the way in until it is stopped by the mounting block.

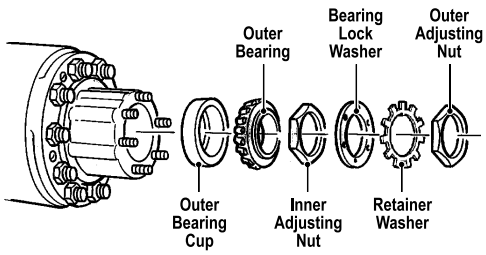
4. Route wire from wheel area to brake ECU. Tie wrap the cable to axle housing.

5. The sensor will properly gap itself when the rotor is re-installed.



Rear Brake Rotor Reassembly



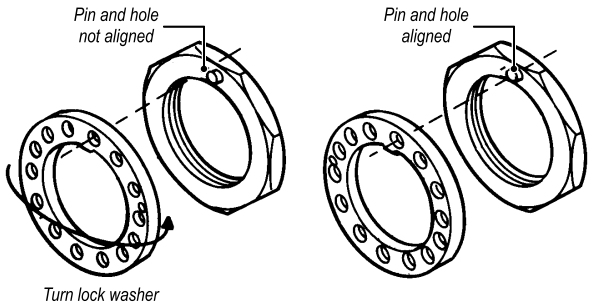


1. Slide the hub/rotor assembly onto the axle. Take care to maintain alignment so as to avoid damaging the inner seal.

2. Prelube the outer wheel bearing. Layout the bearings to be used in a clean area. Dip the clean bearings in the appropriate petroleum or synthetic gear oil until thoroughly saturated.

3. Install the 4" adjusting nut with locking pin facing outward. Torque to 100 ft lb (135.5 Nm). Back the nut off 1 turn. Torque to 50 ft lb (68 Nm). Then back nut off 1/3 turn.

4. Install the wheel bearing lock washer. If the hole in the washer is not aligned with the adjusting nut pin, remove the washer, turn it over, and reinstall. The pin should now be aligned. If not, slightly adjust the inner adjusting nut. Use whichever lock washer hole causes the least movement of the adjusting nut.



5. Install the tabbed retainer washer.

6. Install outer wheel bearing adjusting nut and torque to 100–200 ft lb (136–271 Nm). Verify hub rotation.

7. Bend two tabs of the retainer washer up against the flats of the adjusting nut.

8. Install axle shaft gasket. Use a new gasket if the original was damaged during removal.

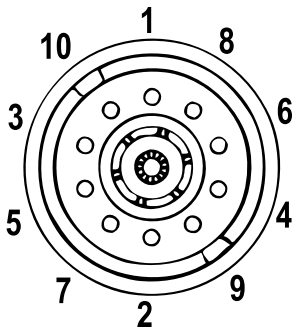
9. Install the axle shaft.

10. Insert a tapered dowel onto each of the axle shaft studs, narrow end first. Install the eight star washers and eight nuts. Working back and forth across the center of the axle, gradually tighten the eight nuts to 150–230 ft lb (203–312 Nm).

11. Reinstall caliper assembly. Torque the four mounting bolts to 320–360 ft lb (434–488 Nm).

12, Check bearing adjustment with a dial indicator and magnetic base. Bearing end play should not exceed .010 in. (.254 mm).

13. Install wheel, and wheel mounting nuts. Draw up the wheel nuts evenly, rotating the wheel a few turns to be sure to remove all free play in the mounting nuts. Then use a calibrated torque wrench to gradually tighten the wheel nuts to 450–500 ft. lbs. (610–678 Nm), working back and forth across the center of the wheel as in the pattern shown:



14. Lower bus. Chock all wheels and check axle fluid level and replenish if necessary.

Wheel Bearing Adjustment

Proper Wheel bearing adjustment is critical to the performance and life of the wheel end components. Improper wheel bearing adjustment can affect wheel bearing and wheel seal life as well as having and adverse effect to the ABS wheel sensing system. The following wheel bearing adjustment recommendation follows Blue Bird Engineering and Technology & Maintenance Council TCM RP618 guidelines.

1. Lubricate the wheel bearing with clean lubricant of the same type used in the axle sump or hub assembly.

2. Install the wheel/ hub and bearing onto the spindle and tighten the adjusting nut to a torque of 200 ft-lbs (272 N-m) while rotating the hub/wheel. This will purge the lubricant and seat the bearing.

3. Back the adjusting nut off one full turn.

4. Re-torque the adjusting nut to 50 ft-lbs (68 N-m) while rotating the wheel.

5. Back off the adjusting nut ¼ turn.

6. Install the wheel bearing adjusting washer and lock washer onto the spindle so that the nipple engages one of the holes on the lock ring. The adjusting nut may be loosened slightly to install the lock.

7. Install the outer jam nut. Tighten to 240-260 ft-lbs (326–353 N-m).

8. Check the bearing end play with a dial indicator by attaching its magnetic base to the hub or brake drum. Adjust the dial indicator so that its plunger is against the end of the spindle with its line of action parallel to the axis of the spindle.

9. Grasp the wheel or hub assembly at the 3 o'clock and 9 o'clock positions. Push and pull the wheel end assembly in and out while oscillating it to seat the bearings. Read the bearing end play as the total indicator movement. Acceptable end play is .001" - .0005" (.025-.127 mm).

10. If the end play is too loose, remove the jam nut and pull the washer away from the adjusting nut. Tighten the adjusting nut to the next alignment hole of the washer. Re-assemble the washer and re-tighten the jam nut to 240-260 ft-lbs. Verify End Play with a dial indicator.

11. If end play is not present, remove the jam nut and pull the washer away from the adjusting nut. Loosen the adjusting nut to the next alignment hole of the washer. Re-assemble the washer and re-tighten the jam nut to 240-260 ft-lbs. Verify End Play with a dial indicator.

Parking Brake

The parking brake is a dual shoe drum type brake, similar in configuration and operating principle to a normal drum brake on a passenger car. However, rather than being mounted at the wheel(s), the single drum unit is mounted on, and rotates with, a yoke on the forward end of the driveshaft. The brake shoe assembly is mounted to the rear housing of the transmission.

When the driver pulls upward on the parking brake lever, the inner cable of a conventional control cable assembly is pulled. This actuates a pivoting bellcrank linkage mounted at the opposite end of the cable, on the top of the transmission. The linkage rotates a cam situated between the two brake shoes, spreading them to force their friction linings against the drum, thereby preventing the drive shaft from turning when the bus is parked.

Adjustment

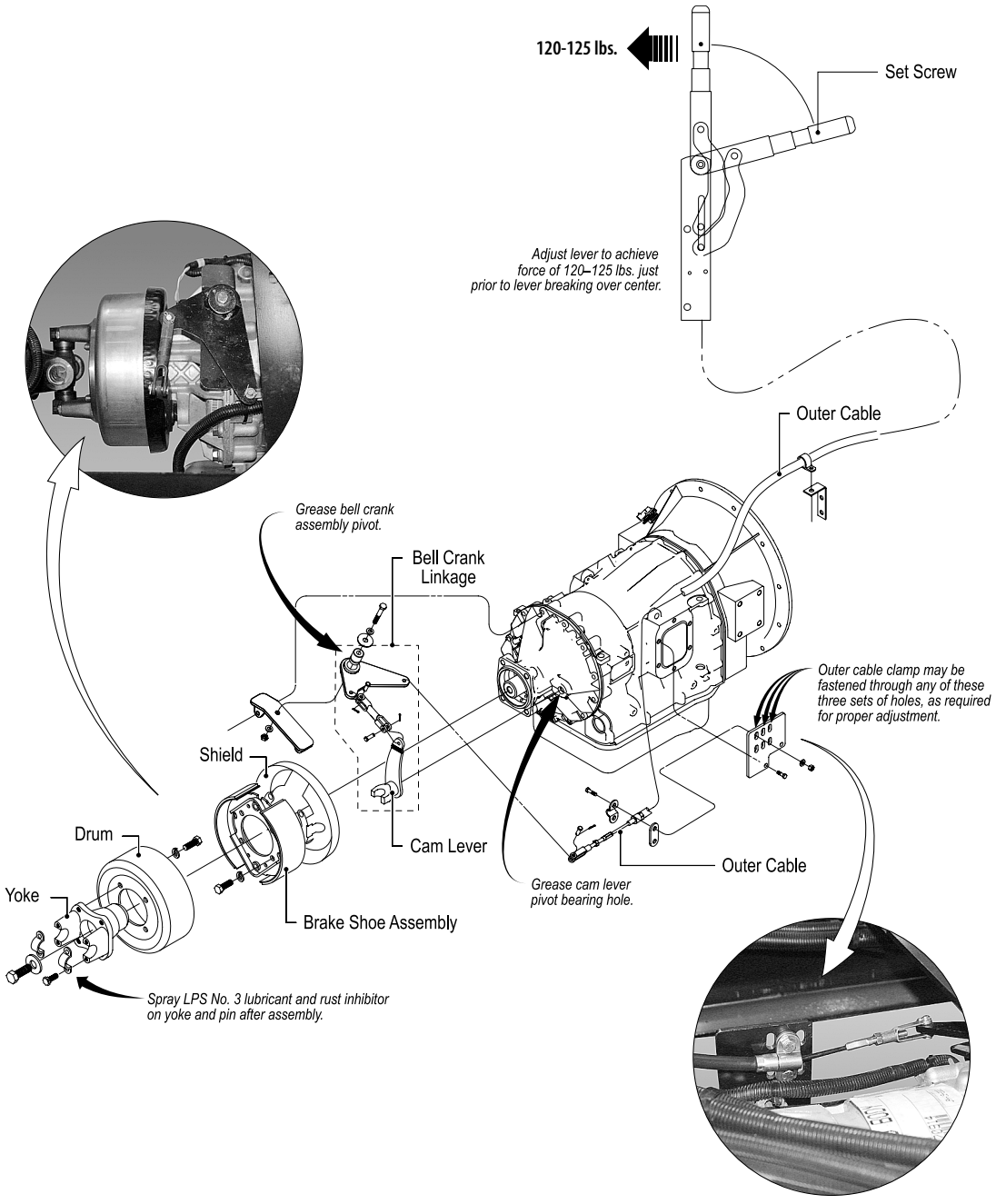
The parking brake should be adjusted so as to require between 90 and 100 pound of force at the parking brake handle just prior to breaking over center and latching in the applied position. Three cable adjustment locations are provided: On the right side of the transmission housing, the outer cable is clamped to a bracket, which has three sets of mounting holes. Any of the three sets of holes can be used to achieve the proper working range for the finer adjustments.

The clevis at the transmission end of the cable is threaded onto the swaged fitting of the inner cable. The effective cable play can be adjusted by:

1. Loosen the clevis lock nut.
2. Disconnect the clevis by removing its cotter pin and clevis pin.
3. Turn the clevis to adjust the cable length. Be sure to always leave at least a few threads of the cable end fitting showing inside the clevis.
4. Reattach the clevis using a new cotter pin and tighten the lock nut.

The cable length can also be adjusted at the parking brake handle:

1. Remove the setscrew in the knurled end of the handle.
2. Rotate the knurled handle to adjust the tightness of the cable.
3. Replace the setscrew and tighten.



Park Brake *(on units with hydraulic brakes)*

Inspection

Parking brake service life will be dependent upon operating conditions and usage. Being designed for normal use with the bus stopped and parked, the drum and shoes of the parking brake are smaller and thinner units than would be used in drum type service brakes. Under normal usage brake lining wear should be minimal. However, the entire parking brake assembly should be disassembled and inspected after any use of it in an emergency stop situation.

Lubrication

A grease fitting is located on the bell crank pivot bushing. Grease should also be applied to the bearing hole on the transmission housing in which the knob of the cam lever pivots.

Removal & Disassembly

To remove the parking brake so as to inspect its brake shoes, drum and other components:

1. Park the bus on a level. Securely block the wheels to prevent the vehicle from moving in either direction.

2. Loosen, but do not remove, the bearing hanger bolts forward of the driveshaft slip joint. This is to allow some axial movement of the driveshaft when unbolting the front shaft from the transmission yoke.

3. Remove the two yoke clamps securing the front driveshaft pivot pin to the yoke.

4 Use a pry bar to carefully push the driveshaft rearward enough to clear the yoke clamps, and carefully lower the front of the drive shaft.

5. Apply the parking brake to prevent the transmission shaft from turning when loosening the yoke mounting bolt. Remove the yoke mounting bolt. Release the parking brake and remove the yoke & drum assembly.

6. To remove the drum from the yoke, mount the yoke in a bench vise with drum facing upward, and remove the four bolts from the inside of the drum.

7. Remove the four bolts which fasten the brake shoe assembly and parking brake shield to the transmission housing. The brake shoes can now be removed from the plate by hand on a workbench.

To remove the bell crank linkage:

8. Remove the cotter pin and clevis pin at the end of the inner cable's screwon clevis.

9. Remove the bell crank pivot bolt. The bell crank linkage can now be removed as an assembly.

Installation

1. Grease the socket hole on the transmission housing in which the cam lever pivots. Insert the pivot ball of the cam lever into the hole. Insert the pivot bolt through the bushing of the bell crank assembly, tightening it to 33 ft. lbs. (44.7 Nm). Connect the clevis end of the cable to the bell crank, using a new cotter pin on the clevis pin.

2. With the yoke mounted in a bench vise, assemble the drum to the yoke, tightening the four mounting bolts to 90 ft. lbs. (122 Nm).

3. Mount the parking brake shield and brake shoe assembly to the transmission housing. Check to ensure that the lugs of the cam lever properly engage the space between the ends of the brake shoes. tighten the four mounting bolts to 90 ft. lbs. (122 Nm).

4. Slip the assembled yoke and drum onto the transmission's splined output shaft. Insert the mounting bolt and handtighten. Apply the parking brake by pushing on the bell crank linkage, to prevent turning of the transmission shaft as the yoke mounting bolt is tightened. Tighten the yoke mounting bolt to 110 ft. lbs. (150 Nm).

5. Assemble the front driveshaft to the yoke using two new yoke straps. Tighten to 45–60 ft. lbs. (6181 Nm).

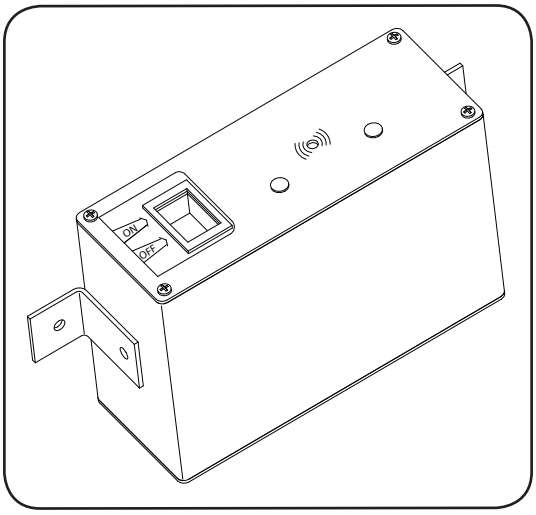
6. Tighten all driveshaft bearing hanger bolts to 29–33 ft. lbs. (39–45 Nm).

Brake Interlock, Hydraulic

As a safety feature, Blue Bird All Americans equipped with wheelchair lift doors incorporate a Mico 691 brake interlock system designed to automatically apply the hydraulic service brakes when the lift door is open. The main components of the interlock system include a motor driven hydraulic pump called the power unit, an actuator which operates in principle similar to a master cylinder, a solid-state control module, and a user interface.

The interlock system has its own separate brake fluid supply and reservoir, and uses DOT 5 fluid. The interlock system's fluid supply is not shared by the service brake system, which uses DOT3 fluid.

Three conditions must be met to supply power to the interlock system control module. The bus must have the ignition key turned to the "on" position, the bus must be stopped (under 3 mph) and the wheelchair lift door opened. These conditions will activate the interlock relay which provides power to the control module.

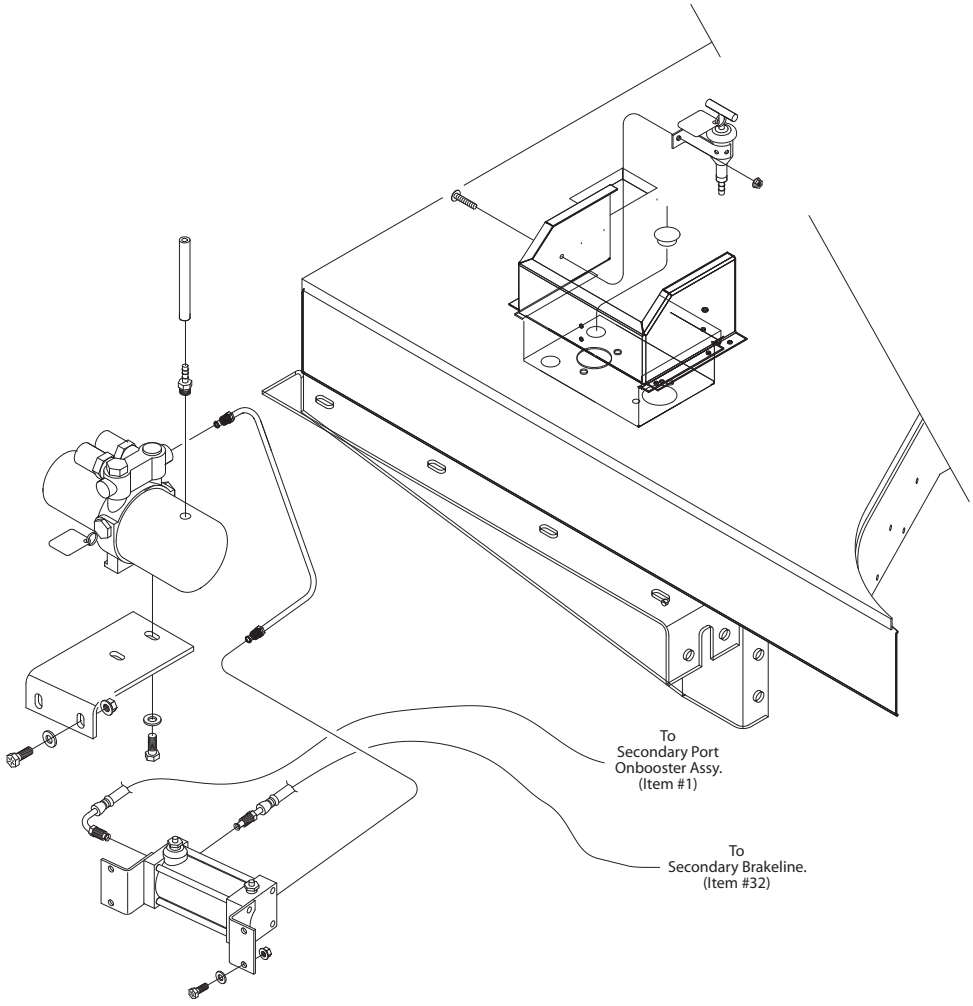


Hydraulic Brake Interlock User Interface

When the interlock system control module is powered, it is activated with a user interface. The control module starts the power unit pumping fluid into the actuator. As the actuator becomes pressurized it isolates the master cylinder and pressurizes the rear service brakes. When lock pressure is reached, the high pressure switch signals the control module to stop the pump. While the pump is stopped, locking pressure is held in the rear brake system. If locking pressure drops, the high pressure switch signals the power unit to turn "on" and restore locking pressure.

When the interlock system is deactivated, the pump reverses and releases pressure. The actuator releases pressure from the brakes and opens the port to the master cylinder. When lock pressure returns to 0 psi a signal from the low-pressure switch stops the pump.

The interlock system is controlled by the control module through the use of a user interface. The user interface incorporates a manual activation, audible alarm and "locked" lamp.



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Hydraulic Brake InterlockSystem

The Power Unit

The power unit incorporates two pressure switches, and is able to reverse flow to release locking pressure. The high pressure switch starts and stops the pump while pressurizing the system. The low pressure switch starts and stops the pump while releasing pressure from the system.

When locking pressure is reached, the high-pressure swithch signals the control module to stop the pump. While the pump is stopped, locking pressure is held. If locking pressure drops, the high pressure switch signals for the power unit to turn on and restore locking pressure.

When the interlock system is deactivated, the pump reverses, releasing pressure from the actuator. When pressure reaches zero psi, a signal from the low pressure switch stops the pump.

The Actuator

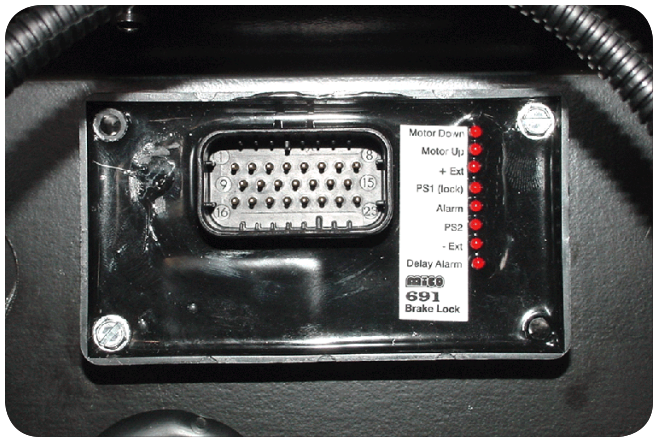
The actuator communicates the hydraulic pressure of the interlock system to that of the All American's service brake system, while keeping the two systems' fluid circuits separate. (The two fluid circuits use different types of brake fluid, which must not be allowed to contaminate each other.)

The power unit's fluid pressure acts upon one side of a piston in the actuator. The opposite end of this piston is in contact with the fluid of the service brake system. When the power unit pumps pressure against the interlock system side of the piston, the piston moves toward the end of its bore, closing the port leading to the service brake master cylinder, and applying pressure to the fluid of the service brake circuit.

When the power unit's pump reverses, the actuator piston moves in the opposite direction, releaving pressure from the service brakes fluid circuit, and opening the port leading to the service brake master cylinder.

Control Module

In addition to acting as a solid-state starter solenoid for the interlock system's power unit motor, the interlock control module also incorporates an LED array which displays the current state of the interlock system. The LEDs indicate the following:



Mico Control Module

Motor Down On when system is releasing pressure. Remains on for three seconds after PS2 goes off.

Motor Up On when system has been activated (proper signal on +Ext or -Ext), until PS1 comes on.

+Ext On when positive signal is present on brown harness wire and/or green user interface wire.

PS1 (lock) On when system is locked at full pressure. Receives ground signal from pressure switch #1 on white wire.

Alarm On when power unit is pressurizing teh system. Controls user interface audible alarm.

PS2 On whenever any pressure is present in the system. REceives ground signal from pressure switch #2 on violet wire.

_Ext On when negative signal is present on gray harness wire.

Delay Alarm Comes on 9 seconds after activating the system if full system pressure has not been attained. Also comes on anytime the power unit runs to repressurize the system.

The input LEDs should be on when receiving their respective signal and off when not. Replace the 691 Control Module when this is not observed.

Control Module Troubleshooting

The following lists possible causes/solutions for particular observed situations:

- When the 691 System is activated, the brakes will not lock up and the power unit does not run.

  1. **No electric power.** Check the battery, fuse, and wiring connection.

2. **High Pressure Switch is inoperative.** Activate the 691 system. If PS1 (lock) LED is on, unplug pressure switch 1. If pump runs, replace pressure switch 1 (high pressure switch), or check for a short to ground in the wiring.

3. **The power unit or control module is inoperative.** Activate the 691 system. If the Motor Up LED is on, check for 12v DC at the power unit connector. Unplug the power unit and attach a voltmeter (+ to blue, - to green) to the connector leading to the control module. If 12v DC is present, replace the power unit. If 12v DC is not present, replace the control module.

4. **The control module is not receiving an input signal.** Activate the 691 system. Check the +Ext and -Ext LEDs. If neither is on, check that a ground signal is present at the gray lead in the main wiring harness, or the green lead from the user interface; or that a positve signal is present on the brown wire in the main wiring harness. If not, determine the reason, and correct.

- When the 691 system is activated, the brakes will not lock up and the power unit continues to run.

1. **The fluid level in the reservoir is low.** Deactivate the 691 system. Verify that the power unit is mounted level. Remove the reservoir breather/filler plug and fill the reservoir with proper fluid to within 1/4" of top. Reinstall breather/filler plug.

2. **Hydraulic leak in either the 691 system or the service brake system.** Inspect all tubing and connections for leaks and tighten or replace as necessary.

3. **The actuator is not functioning properly.** Activate the 691 system. Check the master cylinder reservoir for excessive fluid level. This condition indicates that the seals in the actuator are allowing 691 system fluid to leak into the vehicle service brake system. Replace the actuator and completely flush and refill the service brake fluid circuit.

4. **The power unit is not properly building pressure.** Replace the power unit. (No test to troubleshoot this condition.)

- The 691 system will activate and lock up the brakes, but the power unit keeps running.

1. **High pressure switch is inoperative.** Activate the 691 system. If PS2 LED is off, replace pressure switch 1 (high pressure switch).

- The power unit does not operate to release the brakes when the 691 system is deactivated.

  1. **No electric power.** Check teh battery, fuse, and wiring connections.
  2. **Low pressure switch is inoperative.** Deactivate the 691 system. If the PS2 LED is off, replace pressure switch 2 (low pressure switch).
  3. **The power unit or control module is inoperative.** Deactivate the 691 system. If the Motor Down LED is on, check for 12v DC at power unit connector. Unplug power unit and attach a voltmeter (-to blue, + to green) to the connector leading to control module. If 12v DC is present, replace the power unit. If 12v DC is not present, replace control module.

- The brakes release, but the 691 power unit does not stop running.

  1. **Low pressure switch is inoperative.** Deactivate the 691 system. If the PS2 LED is on, replace pressure switch 2 (low pressure switch).
  2. **The control module is inoperative.** Deactivate the 691 system. If Motor Down LED is off, replace the control module.

- The 691 system and Motor Up LED come on unexpectedly without being activated.

  1. **The control module is receiving false signals.** Be sure stray signals are not being introduced into the external inputs. If the gray wire is not connected to an external input, ensure that it is capped off and not shorting to ground inadvertently. While deactivated, occasional operation of power unit and Motor Down LED is normal to relieve pressure caused by thermal expansion of fluid in the power unit.

- While the 691 system is activated, the power unit and horn activate intermittently.

1. **Change in temperature has caused the system to contract and reduce brake system pressure.** The power unit runs briefly to restore brake system pressure to the orignal lock up pressure. This is considered normal operation as fluid temperature changes.
2. **The service brake system or 691 system has air in it.** Bleed service brake and 691 system.
3. **Hydraulic leak in either the 691 system or service brake system.** Inspect all tubing and connectors for leaks and tighten or replace as necessary.
4. **The power unit is not functioning properly.** Replace the power unit. (No test to troubleshoot this condition.)

Bleeding Procedure

Because the interlock system has its own fluid circuit separate from that of the service brakes, the interlock system must also be bled separately.

1. Make sure the vehicle master cylinder reservoir (not the interlock reservior) is filled with DOT 3 brake fluid, and that the service brake system has been properly bled.
2. Activate the interlock system.
3. Open the bleeder valve on top of the power unit a quarter turn. Close the bleeder screw when a steady stream of fluid is present.

Hydro-Max™ Hydraulic Brake Booster and Master Cylinder

Technical Manual

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Important Service Notes

The information in this publication was current at the time of printing. The information presented in this publication is subject to change without notice or liability.

The information contained in this publication is intended for use by properly trained and equipped professional technicians. It is NOT for the "Do It Yourselfer".

Failure to follow safety and repair procedures can result in personal injury, or damage to vehicles, components and equipment.

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August 2003

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General Description

The Hydro-Max™ is a hydraulically powered brake booster which provides power assist for applying hydraulic brakes. A booster combined with a master cylinder (refer to *Figure 1*) forms the hydraulic brake actuation unit. A typical assembly is shown in *Figure 1*. The booster reduces the pedal effort required to apply the brakes as compared to a non-power system.

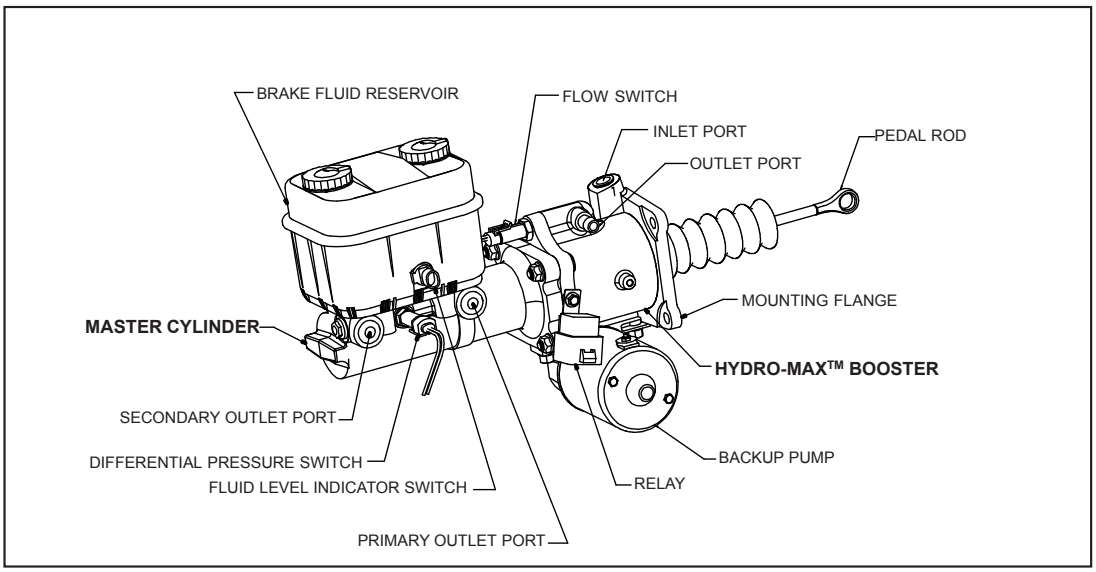

Figure 1 Hydro-Max™ Booster and Master Cylinder Assembly

Hydro-Max™ Booster

The hydraulic booster is comprised of an open center valve and reaction feedback mechanism, a power piston, a 12 and 24-volt backup pump and an integral flow switch. It is powered by either the power steering pump or other hydraulic source. The backup pump provides a secondary power source for the hydraulic booster and is controlled by the integral flow switch.

Master Cylinder

The master cylinder is a split system type with separate fluid chambers, pistons and outlet ports for the front and rear brake circuits. A differential pressure switch, fluid level indicator switch, and remote reservoir are also available.

A typical Hydro-Max™ booster and master cylinder assembly installation in a hydraulic braking system is shown in *Figure 2.*

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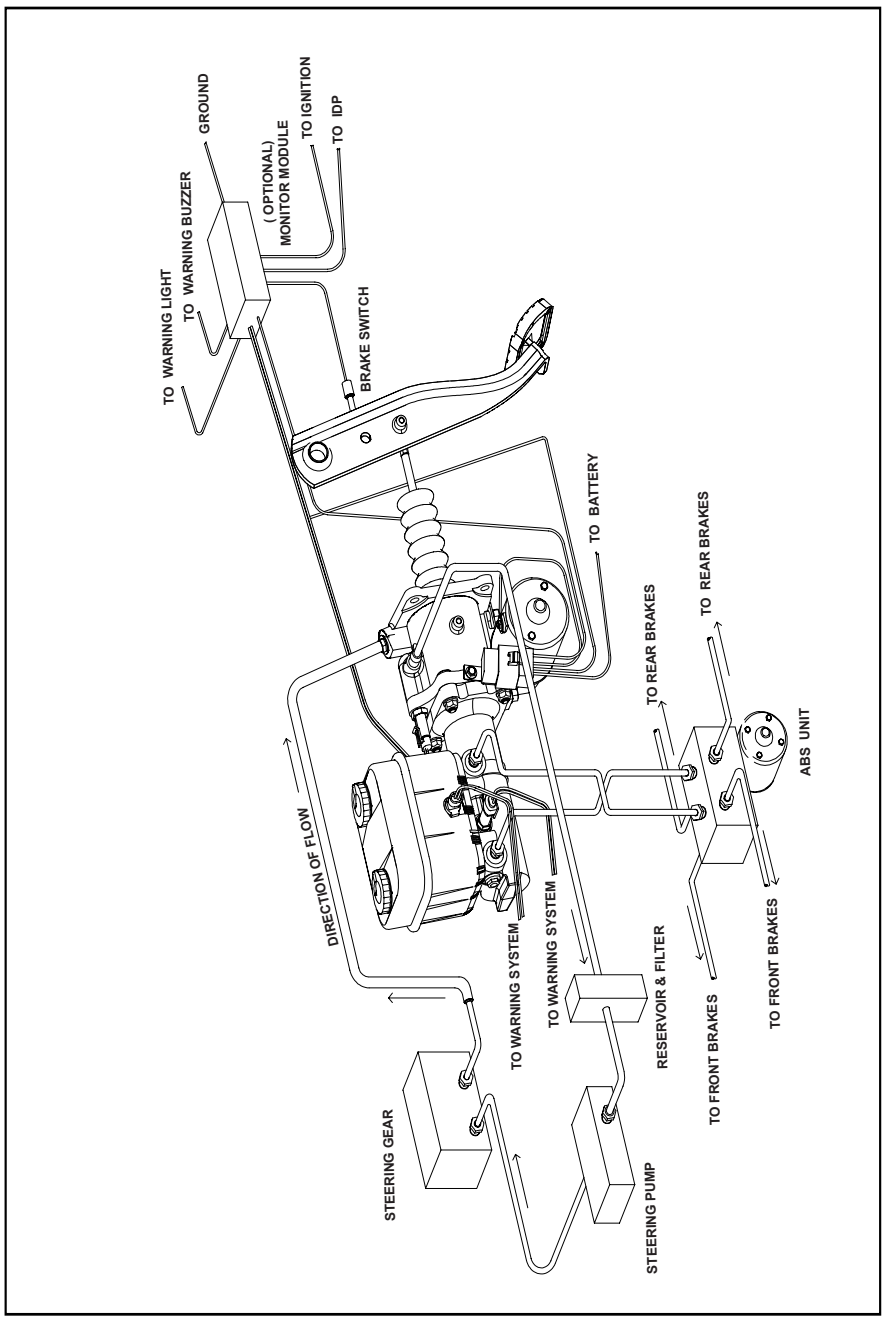

Figure 2 Typical Booster and Master Cylinder Assembly Installation in a Hydraulic Braking System

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Principle of Operation

Hydro-Max™ Booster

During normal system operation, (refer to *Figure 4*) fluid flow from a hydraulic power source (usually the power steering pump) enters the inlet port of the Hydro-Max™ booster, flows through the power piston, around the throttle valve and through the flow switch, exiting through the outlet port.

Force applied to the brake pedal by the vehicle operator is multiplied by the lever ratio of the pedal mechanism to move the pedal rod of the booster. This movement closes the throttle valve, which restricts flow. This restriction of flow, which results in a pressure increase acting on the power piston, applies an amplified force to the master cylinder primary piston. A reaction piston, inside the power piston subassembly, provides the driver "pedal feel" during an application of the brake pedal.

Fluid flow through the flow switch opens the backup pump electrical circuit during normal operation. A separate check valve in the backup pump prevents back-flow through the pump during normal power applications.

In the event normal flow from the power source is interrupted, the backup pump provides the power at a reduced rate for stopping. See *Figure 3* for performance curve. Upon flow interruption, the integral flow switch closes, energizing a relay, providing electrical power to the backup pump.

During backup operation, the pump re-circulates fluid within the booster assembly with pressure built on demand via the throttle valve. Fluid is retained within the booster by the inlet port check valve.

Figure 3 illustrates the typical relationship of master cylinder pressure and input force of the booster.

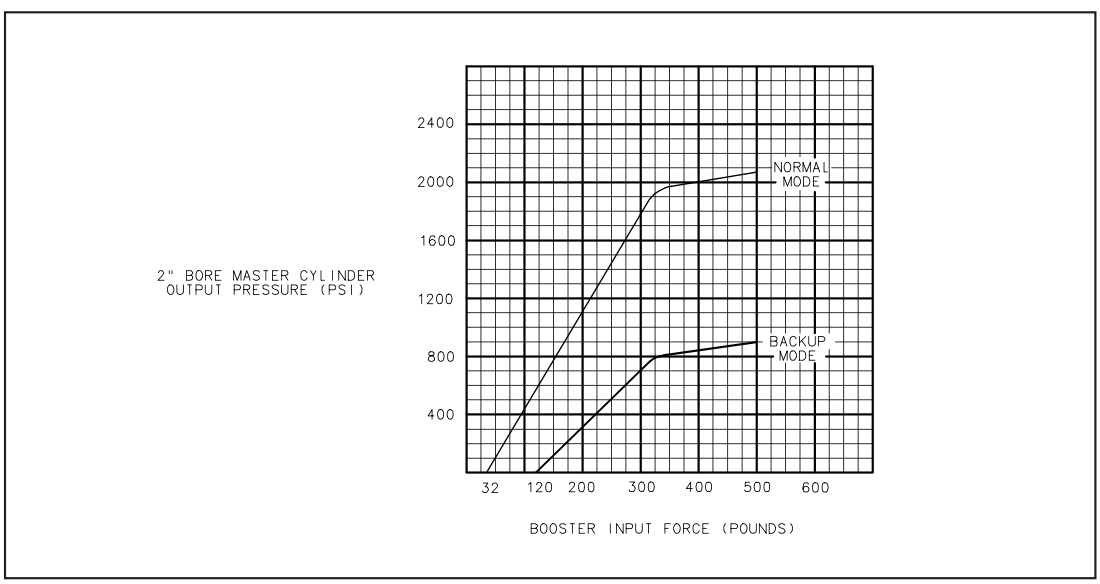

Figure 3 Typical Performance Curve

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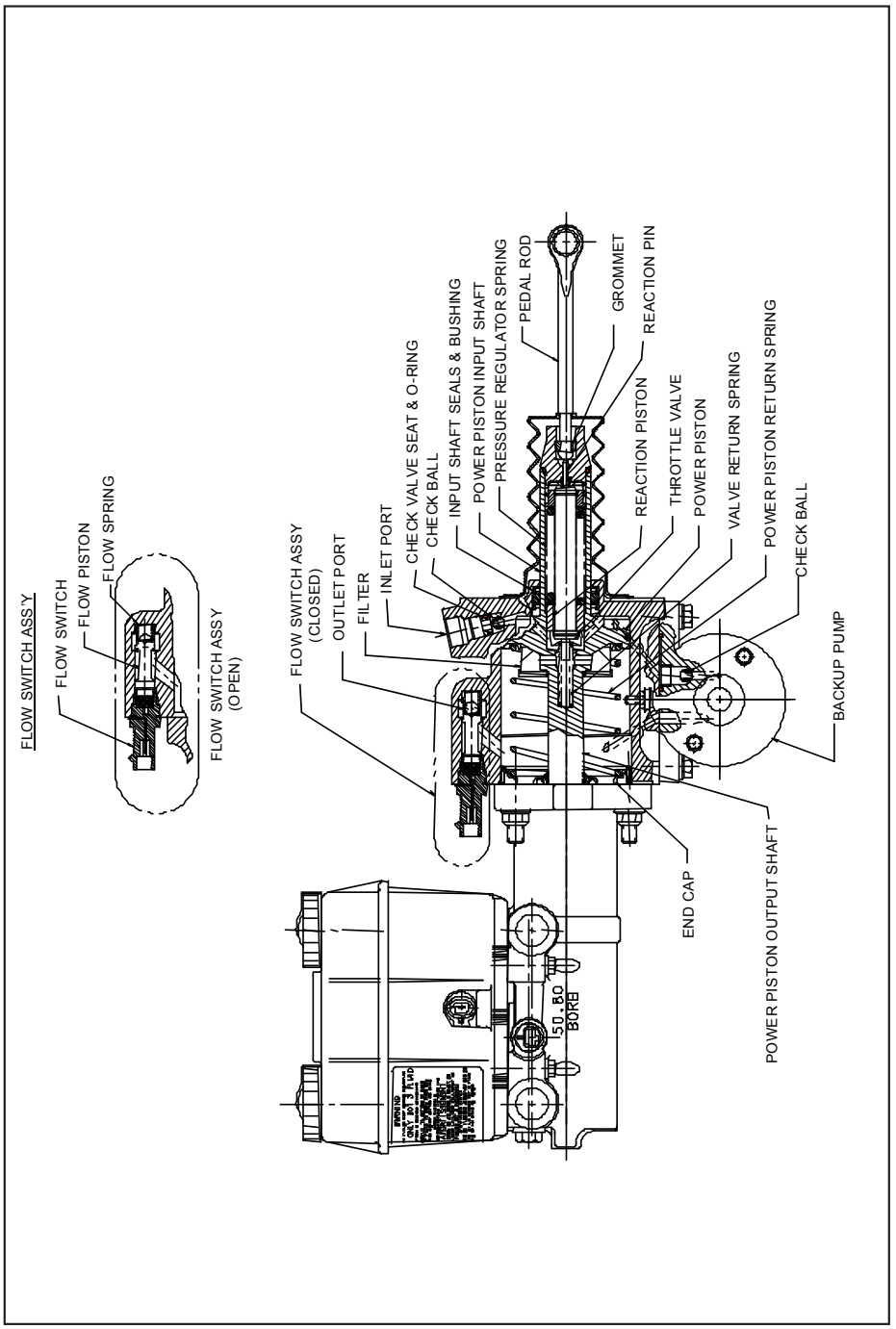

Figure 4 Hydro-Max™ Booster and Master Cylinder

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Master Cylinder

In the released position, (refer to *Figure 5*) actuators of both the primary and secondary pistons are in with their respective compensating valve stems, which project into the cylinder bore. This contact tilts the valves to an open position, which allows hydraulic fluid in the reservoir sections to communicate with the primary and secondary pressure chambers. Each pressure chamber has a piston/actuator subassembly containing a preloaded (caged) spring and return spring.

Initial forward travel of the primary piston moves the primary actuator away from its compensating valve, permitting the valve to seat. Closure of this valve shuts off the passage between the primary pressure chamber and the reservoir section serving the primary chamber.

Further movement of the primary piston creates pressure in the primary pressure chamber, causing the secondary piston and actuator to move. As the secondary piston and actuator move, the secondary compensating valve closes, shutting off the passage between the secondary pressure chamber and the reservoir section serving the secondary chamber. Additional movement of the primary piston causes both chambers to build pressure.

When the load on the primary piston is removed, fluid pressure in each chamber, combined with return spring force, causes the primary and secondary pistons to return to their initial released positions. Each actuator opens its respective compensating valve, reopening the passage between the individual reservoir sections and its associated pressure chamber.

Should the rate of release be great enough to cause a partial vacuum in the chamber, the compensating valve will open to allow replenishment of fluid into the cylinder bore.

Any excess fluid remaining at the end of the stroke due to "pumping" and/or volume change due to temperature fluctuation is released to the reservoir as the compensating valves open.

The primary circuit is separated from the secondary hydraulic circuit. Hydraulic leakage in one circuit does not affect the function of the other circuit.

A fluid level indicator switch is available. It illuminates a light on the dash panel to warn of low brake fluid level in the master cylinder reservoir. A low fluid level can result from brake shoe lining wear, or it can occur if there is an external leak in the vehicle brake system.

A differential pressure switch is available. It illuminates a light on the dash panel to warn when there is a pressure differential between the primary and secondary brake circuits caused by a leak in one circuit. This may occur when one circuit leaks or is improperly bled.

A remote reservoir application is available where under-the-hood space constraints prohibit the use of a conventional booster and master cylinder assembly. In a remote application, the master cylinder reservoir is mounted separately from the master cylinder.

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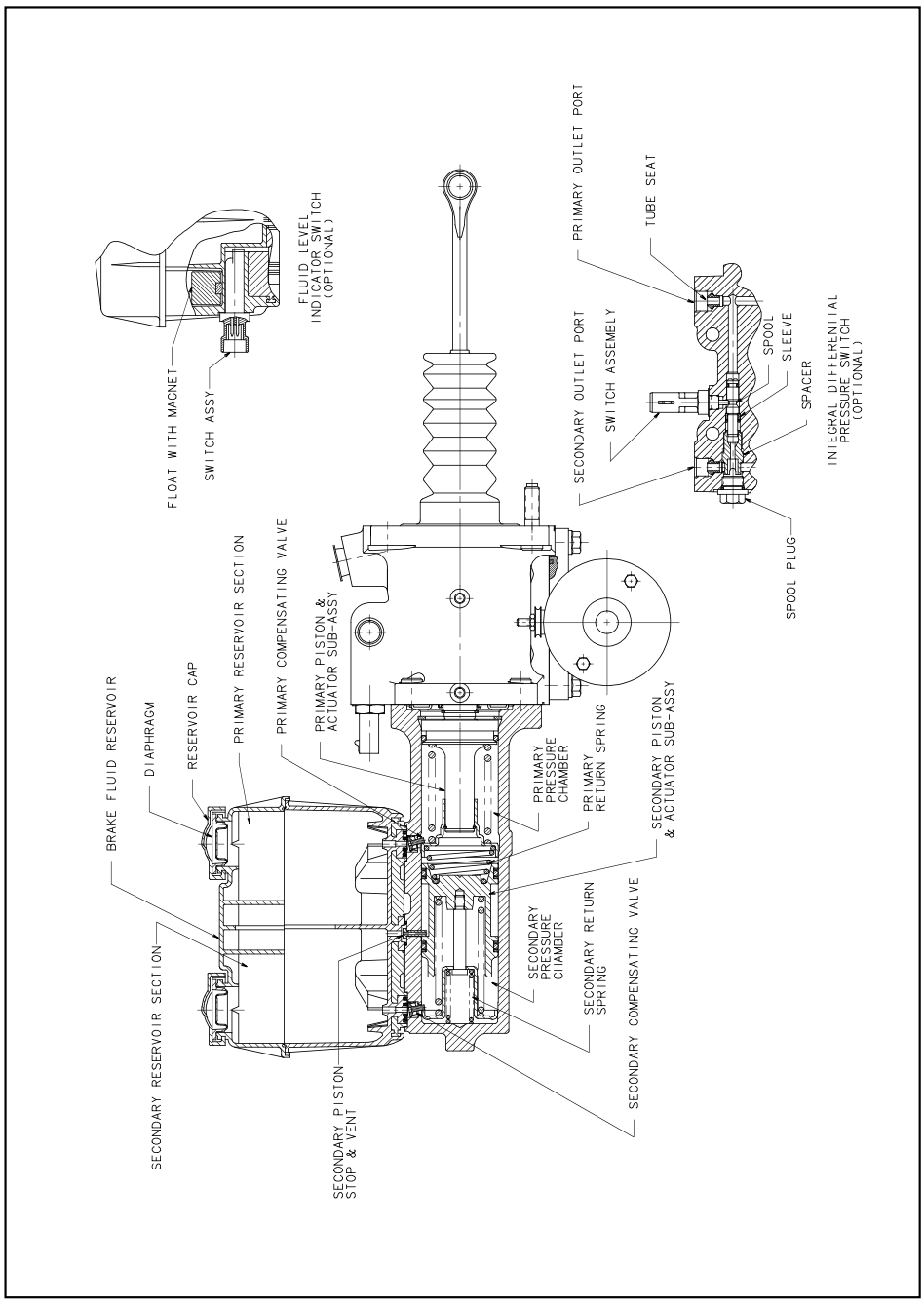

Figure 5 Master Cylinder

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Electrical Operating Systems

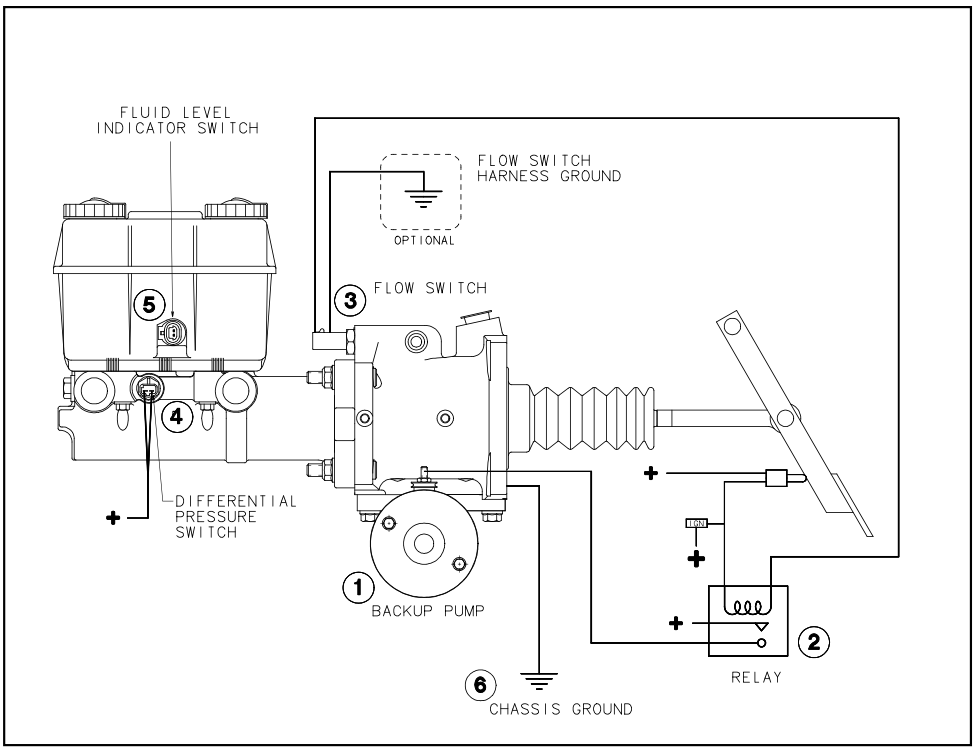

Figure 6 Schematic of Electrical Operating System

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Basic Operation of Hydro-Max™ Booster Assembly and Master Cylinder

Reference *Figure 6* for the following electrical components of the booster and master cylinder.

1. **Backup Pump**: The Hydro-Max™ hydraulic booster has a backup pump which will provide hydraulic boost at a reduced rate if the normal source of fluid is interrupted (refer to *Figure 3*). The signal for operation of the backup pump comes from the flow switch. If normal flow is interrupted, the flow switch will close and activate the relay, which will turn on the backup pump. The backup pump is available for 12 and 24-volt systems.

   The 12-volt backup pump can draw a steady state maximum of 55 amps at a power steering fluid temperature of 100° F. The 24-volt backup pump can have a steady state maximum draw of 27.5 amps at 100° F.

2. **Relay**: An optional relay is available for attachment to the booster. The relay connects to a sealed and mechanically latched wiring connector. The function of the relay is to provide current to the backup pump when triggered by the flow switch.

3. **Flow Switch**: The function of the flow switch is to activate the relay when normal hydraulic power source fluid flow is interrupted, turning on the backup pump. The flow switch has two terminals (A and B). A is positive. B is connected to the booster housing and can be used as an optional harness ground. The flow switch itself is grounded through the booster housing. A sealed and mechanically latched connector connects the flow switch to the backup pump relay circuitry.

4. **Differential Pressure Switch**: The differential pressure switch reacts to a loss of master cylinder hydraulic pressure in either side of the split hydraulic system and can illuminate a warning light at the instrument panel. When pressure is lost in either the primary or secondary circuit of the master cylinder, the switch closes. The electrical switch will remain closed until the malfunction is corrected. When both systems develop normal pressure, the switch will return to center and open the electrical switch circuit. A mechanically latched connector is attached to the switch. The switch has two tabs on a common terminal (positive) and is grounded through the master cylinder.

5. **Fluid Level Switch**: When the fluid reaches a predetermined level (low fluid level), the switch closes and can illuminate a warning light at the instrument panel. A sealed and mechanically latched connector is attached. The switch has two terminals, positive and negative, which are interchangeable.

6. **Chassis Ground**: The booster and master cylinder assembly must be provided with a ground path that will carry the maximum current of the backup pump.

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Electronic Monitor Modules (12-volt only)

Bosch recommends that a monitor module be included to monitor the electrical integrity of the backup system. Bosch offers two types with the following features and functions:

Monitor Module Type I

Features

1. Performs start-up self test for proper electrical signal to reserve backup pump.
2. Continuously test for an open circuit in backup pump.
3. Turns on vehicle warning light and buzzer if any of the above tests indicate a backup system electrical malfunction. The warnings are continuous until the malfunction is corrected or the power is shut off.
4. Conveys signal to provide electrical power to the backup pump via the relay.
5. Provides a centralized housing for diodes.
6. Includes an integral differential pressure switch light check at start up.

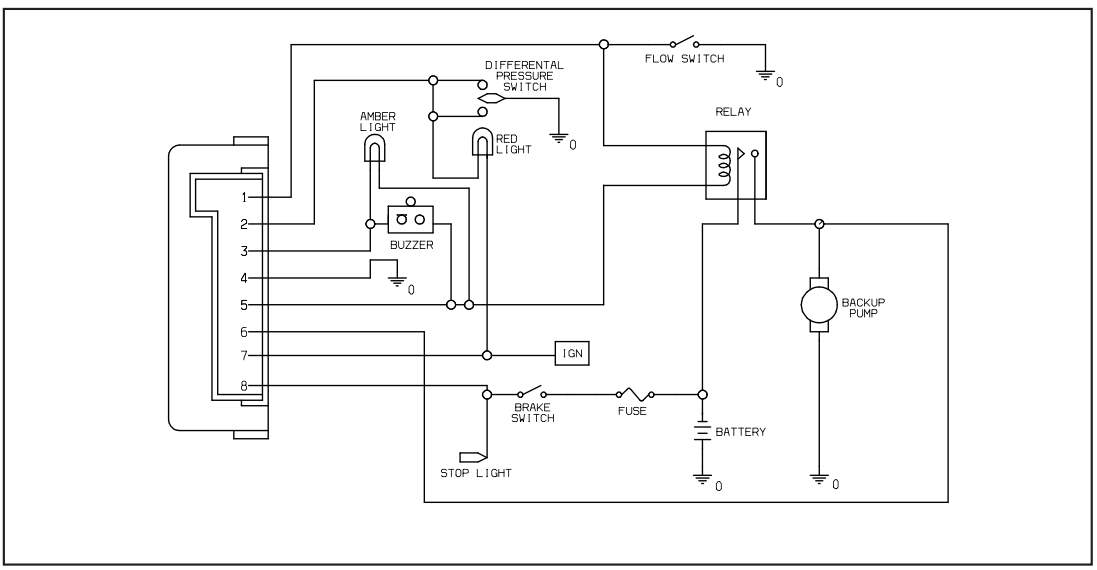

Figure 7 Schematic of Electronic Monitor Module Type I

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Pin Functions

Pin	Function
1	a) Provides path to flow switch to ground for pin 2 to allow test of red light during vehicle start up. b) Suppresses negative voltage transients into pin 5 from the relay coil.
2	Provides path to pin 1 to flow switch to vehicle ground to allow test of red light during vehicle start up. Note: Pin 1 and 2 are connected, with a diode in-between. With the key in the "on" position, the red dash panel light should illuminate anytime hydraulic flow (from the fluid power source) drops to a range of 0.5 to 1.1 gpm. (The range at which flow switch continuity occurs).
3	Open circuit when all is okay, but switches to ground (pin 4) during vehicle start or during a detected fault. Connection to ground turns on warning light and buzzer.
4	Connects monitor module to vehicle ground.
5	Supplies power from module to amber light, buzzer and relay coil. Current flow through this terminal must be limited to 300 mA.
6	a) Monitors for voltage to backup pump during startup. If none detected, pin 3 remains grounded (connected to pin 4). b) Monitors for continuity through the backup pump to vehicle ground during vehicle operation (engine on). Pin 3 switches to ground (pin 4) if continuity is lost.
7	Brings power into module from ignition switch.
8	Brings power into module from brake switch. Only needed when ignition switch is off. Enables backup pump to operate when ignition is off.

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Monitor Module Type II (12 volt only)

Features

1. Performs start-up self test for proper electrical signal to backup pump.
2. Continuously tests for an open circuit in backup pump.
3. Tests for voltage during brake application in brake light circuit and backup pump relay coil circuit on vehicles equipped with dual brake switches.
4. Turns on warning light(s) and buzzer if any of the above tests indicate a backup pump system electrical malfunction. The warnings are continuous until the malfunction is corrected or the power is shut off.
5. Absence or malfunction of the module will not affect backup system operation.
6. Turns on light(s) and buzzer when integral differential pressure switch is activated.

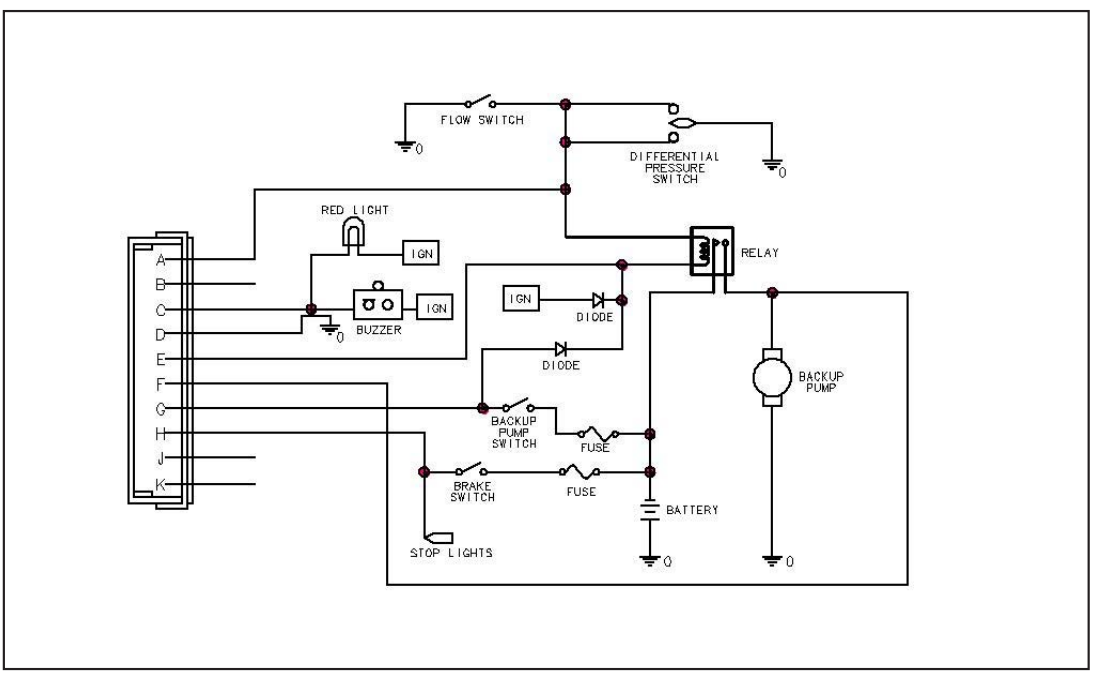

Figure 8 Schematic of Electronic Monitor Module Type II

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Pin Functions

Pin	Function
A	Suppresses negative voltage transients into pin E from the relay coil.
B	Not used.
C	Open circuit when all is okay, but switches to ground (pin D) during vehicle startup or during a detected fault. Connection to ground switches on warning light and buzzer.
D	Connects monitor module to vehicle ground.
E	Power input to monitor module from ignition switch or Hydro-Max™ brake pedal switch.
F	1) Monitors for voltage to backup pump during vehicle startup. If none detected, pin C remains grounded (connected to pin D). 2) Monitors for continuity through backup pump to vehicle ground during vehicle operation (engine on). Pin C switches to ground (pin D) if continuity is lost.
G	Monitors output of the backup pump switch that turns on the backup pump, to allow comparison with pin H. If different for > 14±5 seconds, then pin C switches to ground (pin D) and latches.
H	Monitors output of stop light switch to allow comparison with pin G. If different for > 14±5 seconds, then pin C switches to ground (pin D) and latches.
J	Not used.
K	Not used.

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Application Information

Hydraulic Fluids

The Hydro-Max™ booster uses power steering fluid as the medium of transmitting power.

The master cylinder uses DOT 3 brake fluid per SAE J1703, unless otherwise specified on the top of the reservoir. Service maintenance of motor vehicle brake fluid in motor vehicle brake actuating systems is covered in SAE J1707 information report.

⚠CAUTION

Before using any other type of fluid in the booster or in the master cylinder, contact the Bosch Hydraulic Actaution and Truck Brake Engineering Department. (See inside of front cover).

⚠CAUTION

The booster and the master cylinder use two (2) distinctly different incompatible hydraulic fluids. They must not be mixed. Using the incorrect fluid will permanently damage the seals and can cause the brakes to malfunction.

Brake Fluid Tubing, Hoses and Fittings

Brake fluid lines (tubing and flexible hose) transmit fluid under pressure between the master cylinder and the brakes. The hoses are the flexible links between wheels or axles and the frame or body. The hoses must withstand fluid pressure with minimal expansion and must be free to flex without damage during normal suspension deflection and wheel turns. The following SAE specifications, or their successors if appropriate, are recommended for consideration as a minimum requirement when outfitting a vehicle with brake fluid tubing, hoses and fittings. The hoses should conform to SAE J1401 Hydraulic Brake Hose - Automotive. The tubing should conform to SAE J1047 Tubing - Motor Vehicle Hydraulic Brake System. The fittings should conform to SAE J516a - Hydraulic Hose Fittings, or SAE J512 - Automotive Tube Fittings. Contact the vehicle manufacturer for specific requirements for individual applications.

Booster Fluid Tubing, Hoses and Fittings

The pressure line that supplies fluid to the booster must be a 1/2" diameter flexible or rigid pressure line conforming to SAE J188 and typically designed to run from the steering gear to the Hydro-Max™ inlet. The Hydro-Max™ inlet port utilizes a tube "O" arrangement as shown in *Figure 9* (not supplied by Bosch). For tube flare configuration see *Figure 10.*

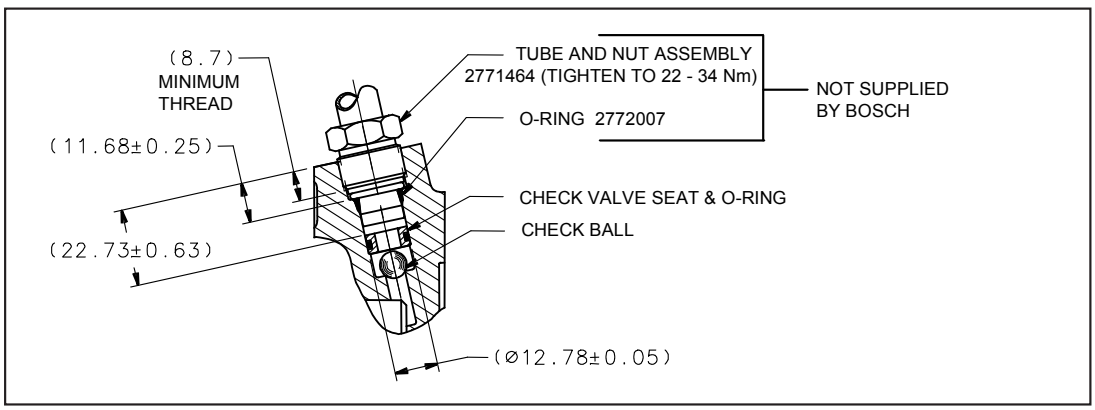

Figure 9 Tube"O" Fitting and O-ring Seal

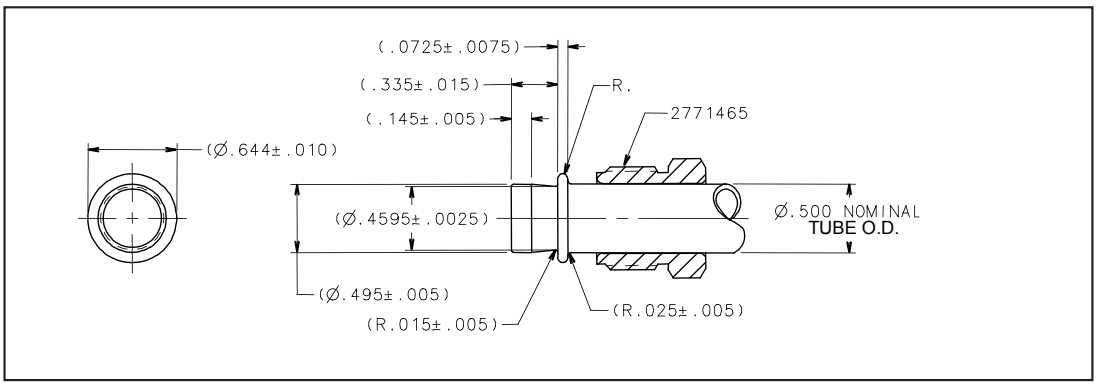

Figure 10 Tube Flare Configuration

The return line must be a 1/2" diameter hydraulic hose attached to the Hydro-Max™ outlet port (See *Figure 11*). The return line and clamp must be selected so that it will withstand worst case vehicle operating conditions, such as back pressures resulting from start up at extremely cold temperatures or from devices installed down stream of the booster.

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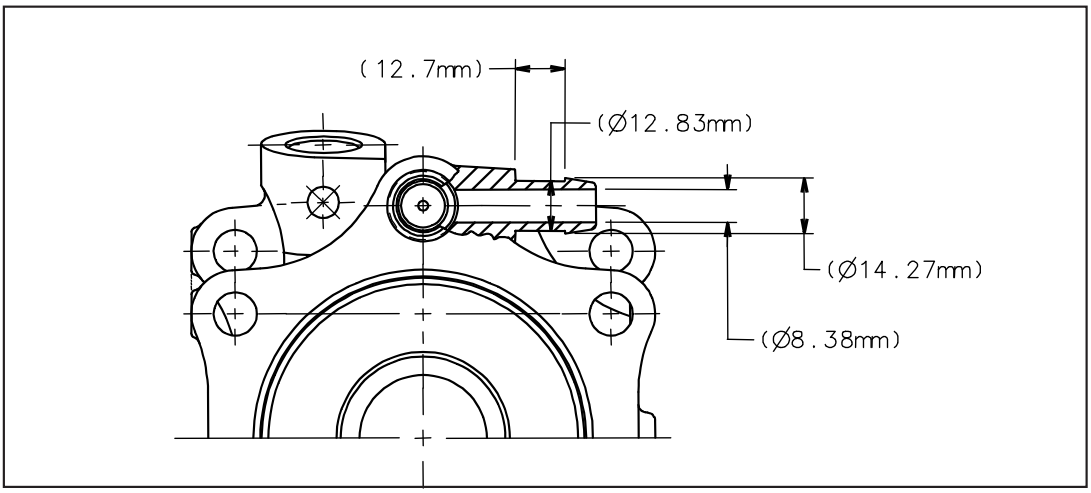

Figure 11 Outlet Port

Booster Fluid Source

The booster is designed to perform in a flow range of 3.2 to 5.0 gpm. Flow rate through the booster can impact vehicle stopping distance; therefore, the vehicle manufacturer must determine the required minimum flow rate. Flow rates below 3.2 gpm can cause slower response times when the booster is applied. Flow rates higher than 5.0 gpm may contribute to the booster self-applying, which will cause brake drag or fluid overheating.

The fluid power source must be capable of supplying 1,000 psi to the booster plus any additional pressure required by other devices in the system such as a power steering gear.

If a power steering gear is used, the steering gear must be "balanced" so that it can handle the pressures generated in the steering gear return line. It must also have an internal relief valve setting lower than the pump relief to allow the steering gear to relieve before the hydraulic pump does. It must also have an internal by-pass to allow manual steering during booster backup system operation. The manufacturer must adhere to the flow path illustrated in *Figure 2*.

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Installation Recommendations

The Hydro-Max™ booster is generally mounted to a vehicle's dash panel. If necessary, the Hydro-Max™ booster and master cylinder may be mounted remotely from the vehicle dash panel and actuated by appropriate linkage.

Four mounting holes are provided in the booster housing through which up to four studs can be pressed. Use of (Grade 5) 3/8-16 or M10 locknuts, having self-contained prevailing torque features that are frictionally resistant to rotation, are recommended.

See *Figure 12* for the three basic pedal rod designs offered. The threaded pedal rod screws into the customer supplied attachment to the brake pedal. The pin that attaches the pedal rod to the brake pedal must insert freely. The attachment mechanism of the pedal rod should be of sufficient strength to prevent linkage binding.

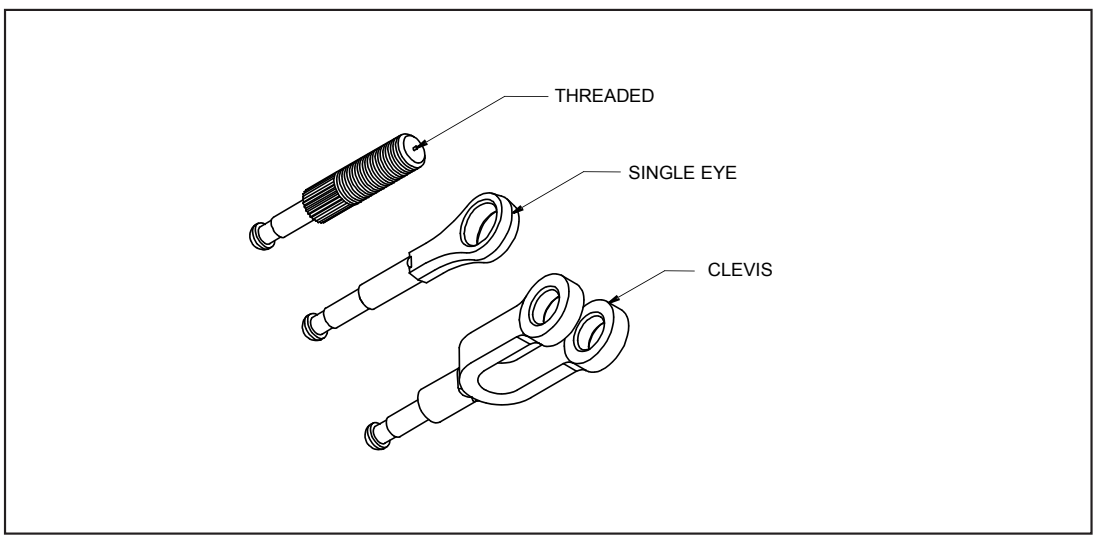

Figure 12 Basic Pedal Rod Designs

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ATTENTION

Regardless of mounting location, the following requirements **must** be followed:

a. Mount the unit such that the pedal rod, throughout full pedal travel, does not articulate more than plus or minus 5^{O} above or below booster centerline. The brake pedal lever must be aligned side to side with the booster centerline to prevent linkage binding.

b. The brake pedal and mechanical linkage **must** provide enough travel to fully stroke both booster and master cylinder, i.e., the brake pedal must not bottom on the floor of the vehicle. A pedal ratio of between 2.8:1and 3.3:1 is recommended to provide the desired "pedal feel".

c. The Hydro-Max^{TM} booster and master cylinder assembly **must** be mounted horizontally.

d. The reservoir of the master cylinder **must** be upright. The backup pump must always be at the bottom of the booster.

e. The unit **must** be protected from environmental and fluid temperatures over 250^{O}F.

General Safety Note

Unique usage or applications of the Hydro-Max^{TM} booster and master cylinder assembly requires input from Bosch and validation by the vehicle manufacturer.

Pedal Return Springs

Any vehicle application utilizing a Hydro-Max^{TM} booster and a brake pedal return spring must have:

1. A properly adjusted pedal stop

2. A limited spring load at the pedal released position.

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Pedal Stop and Proper Spring Load

The pedal stop must be adjusted such that when the brake pedal is fully released, there is no load on the grommet that retains the pedal rod to the Hydro-Max™ booster. When the brake pedal is fully released, the spring load must not be greater than that required to support the pedal weight.

The reason for a properly adjusted pedal stop and for the limitation on spring load is to prevent the spring from pulling on the grommet within the Hydro-Max™ booster and damaging the grommet. The grommet is not designed to be loaded in this manner.

Any adjustment of the brake switch and backup pump must not compromise the adjustment of the pedal stop.

⚠CAUTION

It is a commmon practice to stack vehicles on top of each other to deliver the vehicles. An air cylinder is typically used to apply the brake pedals in the towed vehicles. When installing such a cylinder, be sure that the backup pump turns off when the towing vehicle brake pedal is released.

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TROUBLE SHOOTING

Condition	Cause	Remedy
Hard Pedal	Binding pedal linkage	Contact dealer for service
	Pedal misaligment (side to side)	Contact dealer for service
	Low booster supply flow	Repair/replace power steering pump, check tension in belt
	Power steering pump flow control valve	Repair/replace power steering pump, check tension in belt
	Power steering pump relief valve setting too low	Replace power steering pump
	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Master cylinder	Replace master cylinder
	Booster	Replace booster
	Tube and hose passages are blocked shut	Replace parts containing blocked passages
Excessive pedal travel (pedal goes to the floor)	Improper pedal adjustment	See vehicle service manual for pedal rod adjustment (if system is adjustable)

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TROUBLE SHOOTING

Condition	Cause	Remedy
Excessive pedal travel (pedal goes to the floor)	External leak in brake fluid system	Check all fittings and connections for the master cylinder, calipers, hoses, and tubes, replace if necessary
(continued)	Internal master cylinder leak	Replace master cylinder
	Air in brake fluid system	Bleed system
	Brake linings	Inspect and adjust, or replace brake shoes, if necessary
Pulsating brake pedal	Master cylinder	Replace master cylinder
	Weak brake hoses that expand under pressure	Replace hoses
	Poor quality brake fluid (low boil point)	Drain the system, flush and refill with the recommended fluid.
	Brake self adjusting mechanism	See vehicle service manual (if brakes are adjustable)
Soft, spongy brakes	Air in hydraulic brake system	Bleed brake system
	Poor quality brake fluid (low boil point)	Drain the system, flush and refill with recommended fluid
	Weak brake hoses that expand under pressure	Replace defective hoses
Actuated pedal does not return	Binding pedal linkage	Contact dealer for service

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TROUBLE SHOOTING

Condition	Cause	Remedy
Actuated pedal does not return *(continued)*	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Master cylinder	Replace master cylinder
	Binding booster	Replace booster
	Self applied booster (fluid flow too high)	Repair or replace power steering pump.
Pulsating brake pedal	ABS operation	See appropriate service manual
	Wheel bearings loose or worn	See appropriate service manual
	Excessive rotor hickness variation	See appropriate service manual
	Parking brake control valve (HR1) has internal leak	See appropriate service manual
Brake self apply	Self applied booster (fluid flow too high)	Repair or replace power steering pump
	Constricted master cylinder reservoir vent	Clean vent passage in reservoir cap
Dragging brake	Self applied booster (fluid flow too high)	Repair or replace power steering pump

BOSCH

TROUBLE SHOOTING

Condition	Cause	Remedy
Dragging brake (*continued*)	Stuck or bound caliper pins or rails	See appropriate service manual
	Binding booster	Replace booster
	Binding pedal linkage	Contact dealer for service
	Master cylinder	Replace master cylinder
	Soft or swollen master cylinder seals due to brake fluid contamination	Flush out old brake fluid then replace master cylinder and add new brake fluid
	Tube and hose passages restricted	Replace the parts containing the restriction
Noise / Whistle	Inherent in some boosters (whistle)	None - Does not affect operation
Backup pump operates continuously	Brake switch	See vehicle service manual
	Monitor module	See vehicle service manual
	Relay	See vehicle service manual
	Flow switch	Remove switch components, clean, inspect for damage or contamination and replace if necessary
	Binding pedal linkage	Contact dealer for service

BOSCH

TROUBLE SHOOTING

Condition	Cause	Remedy
Backup pump does not operate	Same as above	Repeat as above
	Electrical ground	See service manual
	Backup pump	Replace backup pump
Leakage	Master cylinder	Replace master cylinder
	Booster	Replace booster
	Master cylinder reservoir vent caps	Replace diaphragms and caps
	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Backup pump mounting seals	Replace seals
	Flow switch seal	Replace o-ring
	Hydraulic fittings and connections	See vehicle service manual, tighten and replace if necessary
Silicone floating in master cylinder	This material is an assembly lubricant	None - Does not affect operation

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BOSCH

TROUBLE SHOOTING

Condition	Cause	Remedy
Fluid level indicator light comes on	Low fluid level	Inspect brake pads, replace as necessary, add fluid as required
	Fluid level indicator switch	Replace master cylinder
	Brake pads worn out	Inspect brake pads, replace as necessary, add fluid as required
Brake indicator light and buzzer malfunction	Vehicle specific	See vehicle service manual

Correspondence concerning this manual should be addressed to:

Robert Bosch Corporation
Hydraulic Acutation & Truck Brake Engineering
401 North Bendix Drive
South Bend, Indiana 46628

Fax: 574-237-2210

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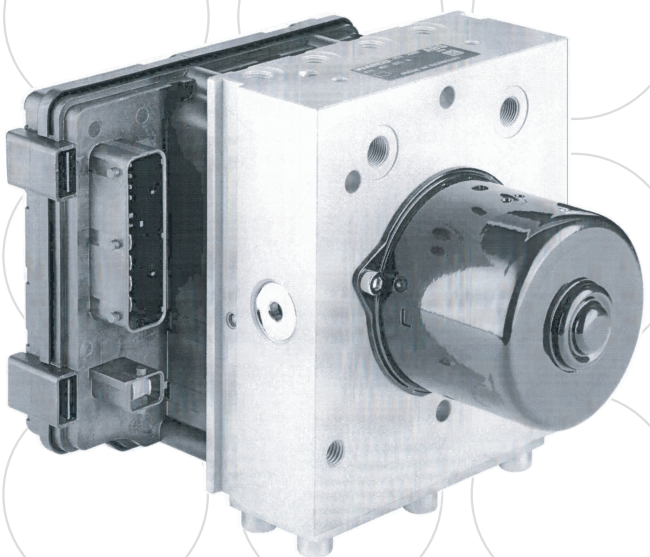
MERITOR WABCO

Maintenance Manual MM-0677

Hydraulic Anti-Lock Braking Systems (HABS) for Medium-Duty Trucks, Buses and Motor Home Chassis

For E Version Hydraulic ABS

Revised 10-08



Service Notes

About This Manual

This manual provides instructions for Meritor WABCO's E Version hydraulic anti-lock braking system (HABS) for medium-duty trucks, buses and motor home chassis.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at arvinmeritor.com to access and order product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components. Meritor WABCO publications are also available on our website:

www.meritorwabco.com

Literature on Demand DVD (LODonDVD)

The LODonDVD contains product, service and warranty information for ArvinMeritor and Meritor WABCO products. To order the DVD, visit Literature on Demand at arvinmeritor.com and specify TP-0742.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

Information contained in this publication was in effect at the time the publication was approved for printing and is subject to change without notice or liability. Meritor WABCO reserves the right to revise the information presented or to discontinue the production of parts described at any time.

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Asbestos and Non-Asbestos Fibers

⚠ ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

2. Respiratory Protection. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up**.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

⚠ NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. Respiratory Protection. OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m^3 as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal**.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

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1 Introduction

Maintenance

Manual Information

This manual contains service information for the Meritor WABCO **E Version** hydraulic ABS. For earlier versions of Meritor WABCO HABS, refer to:

- MM38 **C Version** HABS
- MM39 **D Version** HABS

Copies of these manuals are posted on our website:

meritorwabco.com.

Overview

Meritor WABCO Hydraulic Anti-lock Braking System (HABS) is an electronic wheel speed monitoring and control system used on medium-duty trucks, buses and motor home chassis equipped with a hydraulic brake system.

E Version HABS consists of an electronic control unit (ECU) mounted directly on a modulator valve. Typically, the modulator valve is mounted on the frame rail of the vehicle. Figure 1.1.

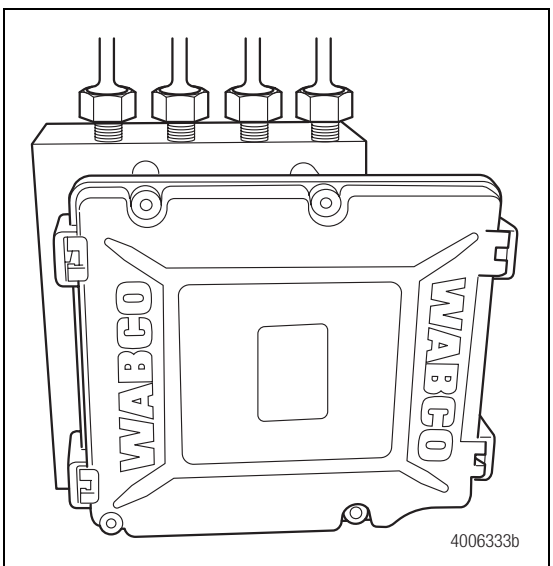


Figure 1.1

How Hydraulic ABS Works

ABS wheel sensors detect wheel speeds. The sensors generate signals that are transmitted to an ECU. If the wheels start to lock, the ECU signals the modulator assembly to regulate the brake pressure of each locking wheel.

During an ABS stop, a solenoid valve in the modulator assembly is rapidly pulsed; that is, it opens and closes several times per second to control the brake pressure. When this occurs, drivers may notice a pulsation of the brake pedal.

An ABS warning lamp on the vehicle instrument panel alerts the driver to a possible system fault and provides blink code information to diagnose the system.

If the ABS warning lamp comes on during normal vehicle operation, drivers may complete their trip, but are instructed to have their vehicle serviced as soon as possible.

In the unlikely event of an ABS system malfunction, the ABS in the affected wheel will be disabled and will return to normal braking. The other sensed wheels may retain their ABS function. Do not rely on the ABS functioning for any of the sensed wheels. Have the vehicle serviced as soon as possible.

1 Introduction

System Layout

A typical Meritor WABCO E Version HABS installation is illustrated in Figure 1.2.

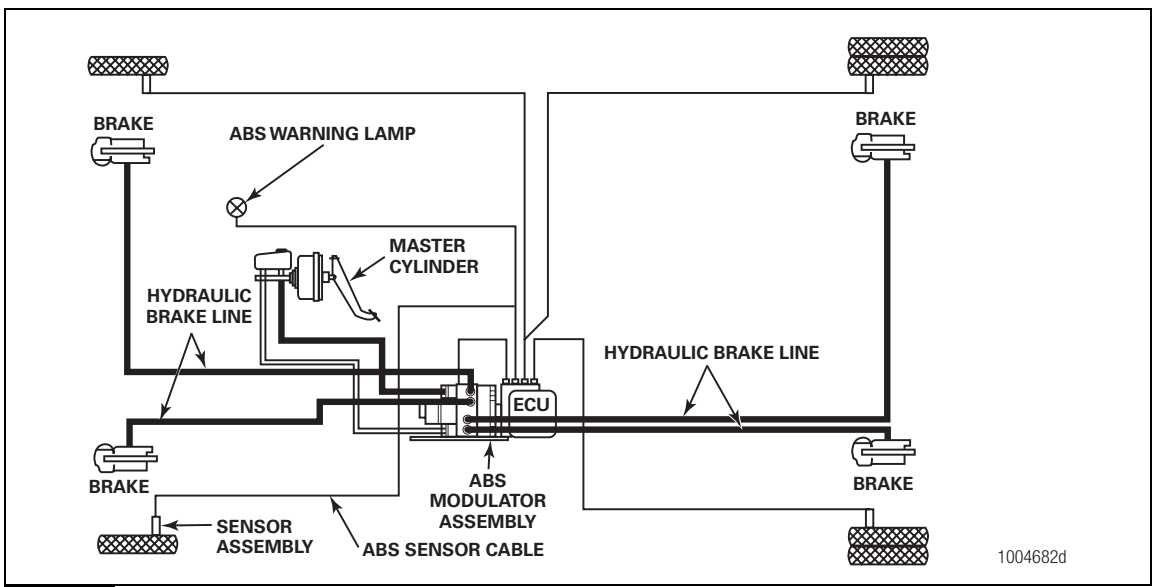


Figure 1.2

The ABS modulator assembly may be mounted in any orientation as long as the modulator is **below** the master cylinder and **above** the wheel cylinders.

System Components

The following components make up Meritor WABCO E Version HABS.

Electronic Control Unit (ECU)

The electronic control unit (ECU) processes sensor signals and generates solenoid valve commands to reduce, maintain or reapply brake pressure. Figure 1.3.

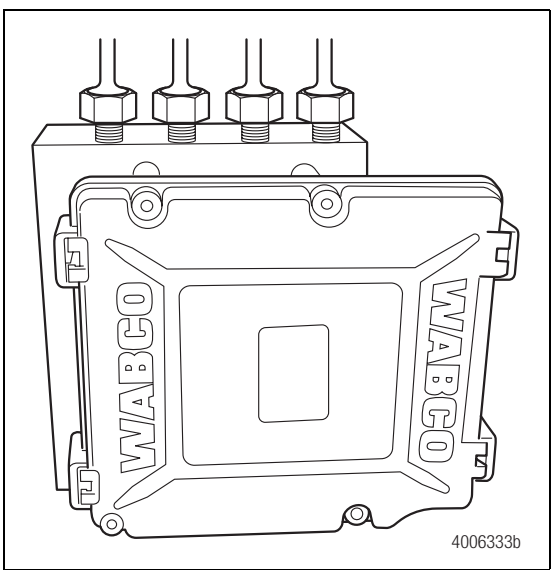


Figure 1.3

1 Introduction

Modulator Assembly

⚠ CAUTION

The modulator assembly contains brake fluid. Handle the modulator assembly with appropriate care. Do not expose the modulator assembly to impact loads or excessive vibrations. Do not blow compressed air into the hydraulic ports. Mishandling the modulator assembly may lead to component damage and system failure.

The modulator assembly houses the HABS solenoid control valves, one inlet valve and one outlet valve per wheel, a pump motor and two low pressure accumulators. Figure 1.4.

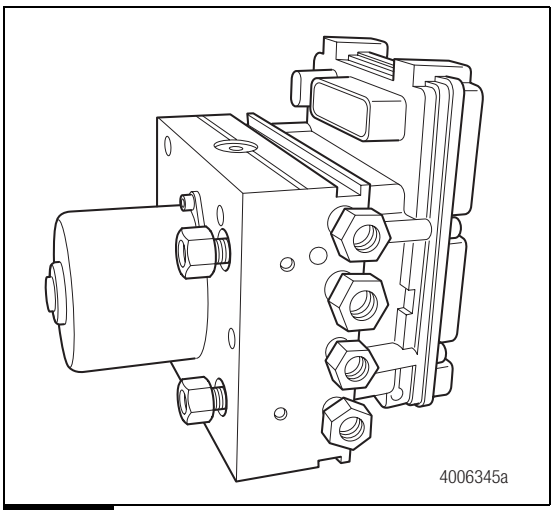


Figure 1.4

Sensors

Sensor with Molded Socket

- Used to measure the speed of a tooth wheel rotating with the vehicle wheel.
- Produces an output voltage proportional to wheel speed. Figure 1.5.

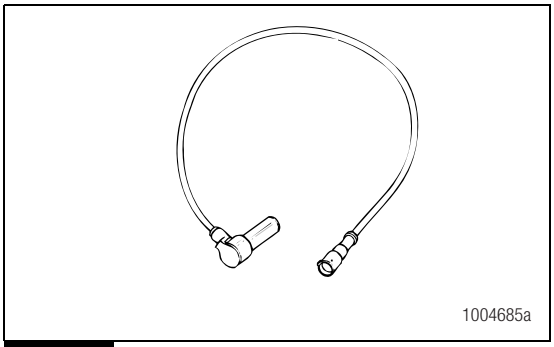


Figure 1.5

Sensor Spring Clip

- Holds the wheel speed sensor in close proximity to the tooth wheel. Figure 1.6.

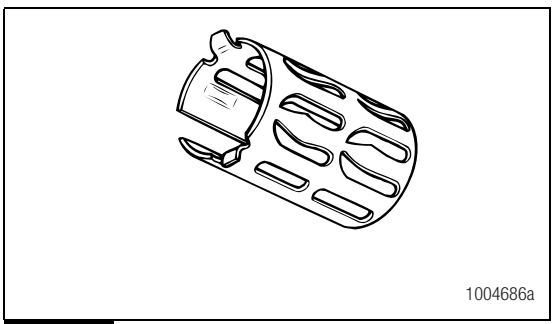


Figure 1.6

Tooth Wheel

- A machined or stamped ring mounted to a machined surface on the hub of each ABS-monitored wheel. Figure 1.7.

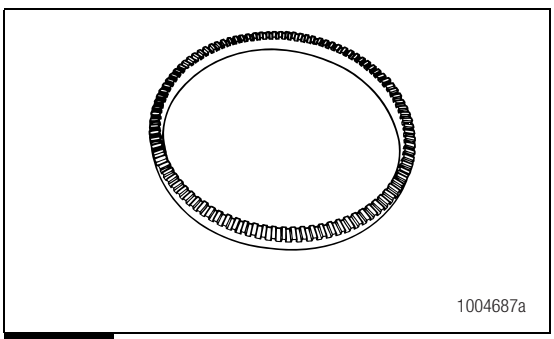


Figure 1.7

1 Introduction

Sensor Extension Cables

- Two-wire cable with molded-on connector. Figure 1.8.
- Connects the wheel speed sensor to the ECU.

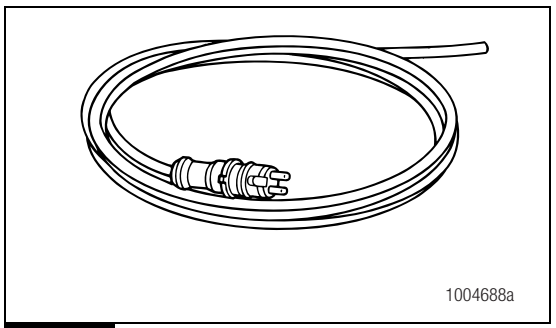


Figure 1.8

ABS Warning Lamp

- Located on vehicle instrument panel. Figure 1.9.
- Alerts drivers to a possible system fault.
- Used by service personnel to display blink codes (optional feature).
- ABS warning lamp is not provided by Meritor WABCO.

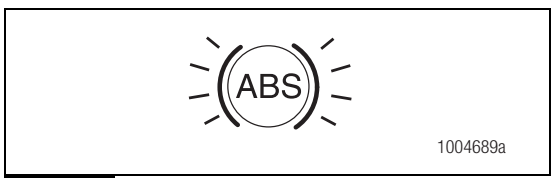


Figure 1.9

TOOLBOX™ Software

- A PC-based diagnostics program.
- Displays system faults and wheel speed data, tests individual components, verifies installation wiring and more.
- Runs in Windows® ME, XP, 2000 or Vista. Figure 1.10.

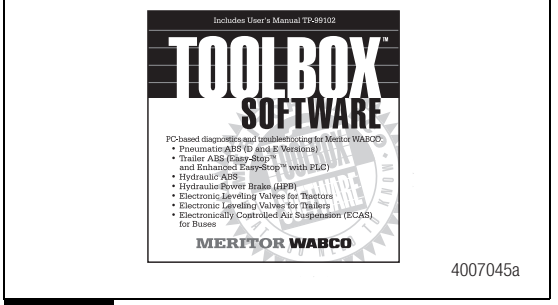


Figure 1.10

NOTE: An RS232 to J1708 converter box is required.

The converter box and the program are available from SPX. Call 800-328-6657.

Maintenance

General Information

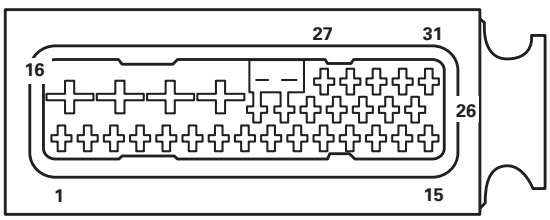
There is no regularly scheduled maintenance required for Meritor WABCO E Version Hydraulic ABS. However, ABS does not change current vehicle maintenance requirements. For example, it is important that the vehicle brake fluid level be correctly maintained.

Wiring Diagrams

System Wiring Information

Pin identification is shown in Figure 2.1. Wiring may vary according to the vehicle. Refer to the vehicle specifications for specific wiring diagrams. A typical Meritor WABCO Hydraulic ABS wiring diagram appears in Figure 2.2.

PIN IDENTIFICATION FOR HABS WIRE HARNESS CONNECTORS TO THE ECU



(9511)

Count from the pin number at the end of each row, identify pin assembly to measure. Connector view shows the back of the connector.

Pin #	Circuit Label
1	Ignition 12v
2	3rd Brake Relay (optional)
3	Not Used
4	Not Used
5	Not Used
6	Reference Ground
7	Not Used
8	Not Used
9	Not Used
10	Not Used
11	Not Used
12	Not Used
13	Not Used
14	J1939 + High – (optional)
15	J1939 – Low – (optional)

Pin #	Circuit Label
16	Pump Motor Supply 12v+
17	Solenoid Valve Supply 12v+
18	Pump Motor Ground –Gnd
19	Solenoid Valve Ground –Gnd
20	Not used
21	ABS Warning Lamp Relay
22	Rear Right Wheel Speed Sensor
23	Rear Left Wheel Speed Sensor
24	Front Left Wheel Speed Sensor
25	Front Right Wheel Speed Sensor
26	J1587 Diag. B + Low
27	Rear Right Wheel Speed Sensor
28	Rear Left Wheel Speed Sensor
29	Front Left Wheel Speed Sensor
30	Front Right Wheel Speed Sensor
31	J1587 Diag. A + High

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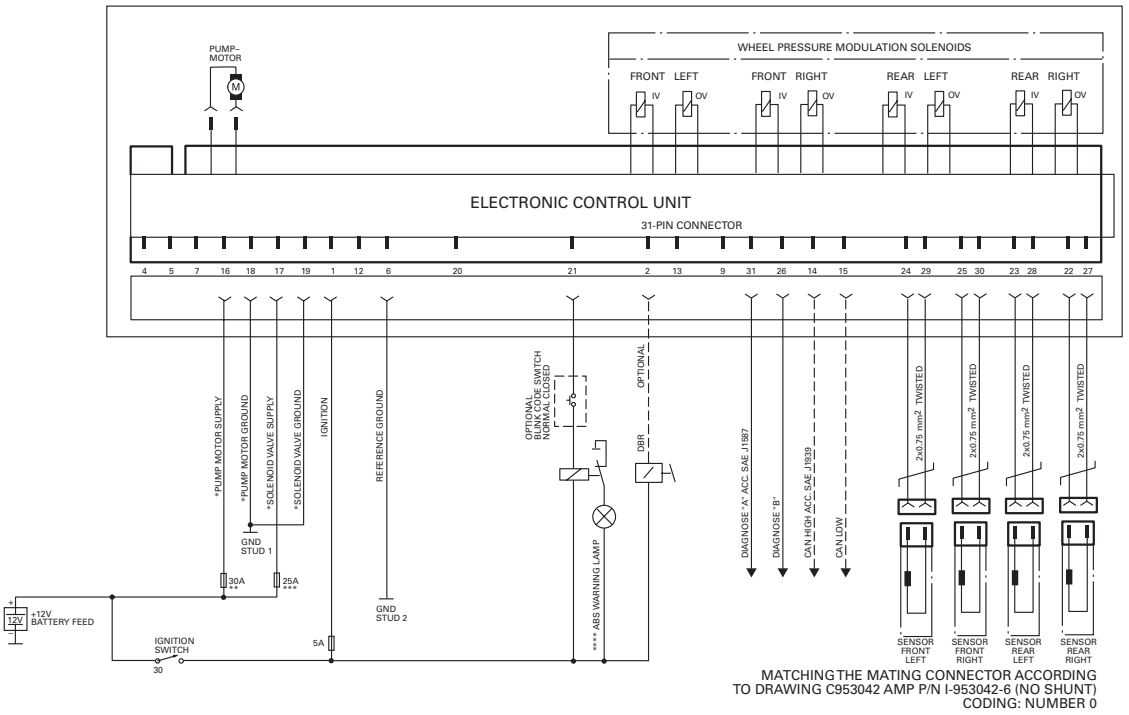
Figure 2.1

2 Troubleshooting and Testing

WIRING DIAGRAM
HYDRAULIC ABS E-VERSION HABS



NOTES:
Electric cables without marks:
AWG 18 (SAE J 1128 TYP: TXL-CABLE)
respectively 1 mm²
Blade type fuses corresponding to ISO/DIS 8820
Abbreviations: IV — Inlet Valve
OV — Outlet Valve

*** Wire size AWG 12 (SAE J 1128 TYP: GXL-CABLE)**
Respectively Min. 3 mm²:
Total resistance including crimp = 0.04 ohms.
Corresponds to an overall length of 6 meters.
**** According to SAE J 1284 or SAE J 1888.**
***** According to SAE J 1284.**
****** ABS lamp circuit (optional).**

4006173d

Figure 2.2

System Diagnostics

Use Meritor WABCO's PC-based diagnostic program, TOOLBOX™ Software, or standard blink codes to diagnose hydraulic ABS faults. Information for using standard blink codes appears in Table B in this section.

Meritor WABCO TOOLBOX™ Software

NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX™ Software.

If you have TOOLBOX™ Software installed on your computer, use it to identify system faults. Then, follow the on-screen repair information to make the necessary repairs or replacements.

To display Hydraulic ABS faults, use the pull-down menu or the HABS icon, Figure 2.3, to select HABS (Hydraulic ABS) from the **Main Menu**. The **Hydraulic ABS Main Menu** will appear. Figure 2.4.

Select the View ECU Faults icon or select Display Faults to use the pull-down menu. Figure 2.5. This will display the **Fault Information** screen. Figure 2.6.

2 Troubleshooting and Testing

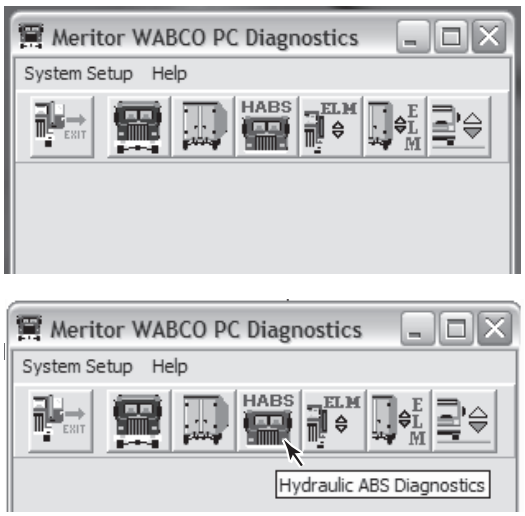


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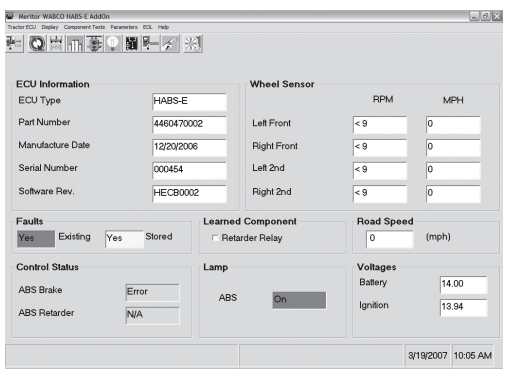
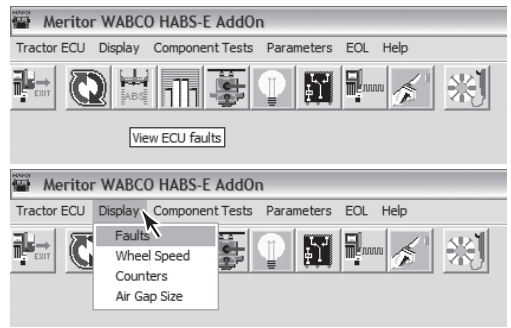
Figure 2.3



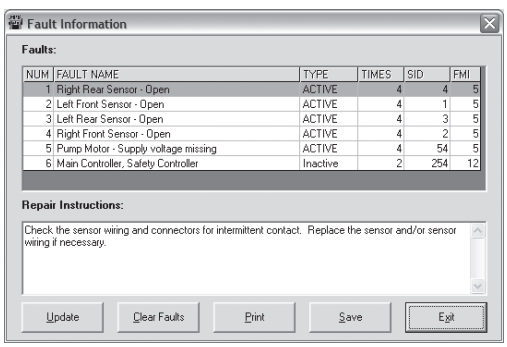
4006577a

Figure 2.4



1004697b

Figure 2.5



1004698b

Figure 2.6

The **Fault Information** screen contains a description of the fault. Repair instructions for each fault appear at the bottom of the screen.

Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the ***Update*** button to refresh the fault information table.

After making the necessary repairs, use the ***Clear Faults*** button to clear the fault. Use the ***Update*** button to refresh the fault information table and display the new list of faults.

Most faults require an ignition cycle and/or test drive above 5 mph to verify fault resolution. Also check the ABS warning lamp to ensure the system functions correctly.

2 Troubleshooting and Testing

Blink Code Diagnostics

Definitions

ABS Warning Lamp: This lamp, located on the vehicle instrument panel, serves two purposes:

1. Alerts drivers or service personnel to a possible fault in the hydraulic ABS, as follows:

   IF the ABS warning lamp comes on briefly then goes OFF when the ignition is turned ON . . . . . there are no active faults in the hydraulic ABS

   IF the ABS warning lamp comes on and **stays on** AFTER the ignition is turned ON **and**

   The vehicle is driven in excess of four mph (6 km/h) . . . **There may be an active fault in the hydraulic ABS**

   IF the ABS warning lamp comes on and stays on **and**

   Goes OFF after the vehicle is driven in excess of four mph (6 km/h) or illuminates intermittently during driving . . . **There may be a stored fault in the hydraulic ABS**

2. Displays diagnostic blink codes for easy servicing.

   Blink Code: A series of blinks or flashes that describe a particular ABS system condition. Refer to Table B and Table C in this section for blink code identification.

   Blink Code Diagnostics: The ability of the Meritor WABCO ECU to sense faults in the ABS system and to define these faults via blink codes.

   Blink Code Switch: A momentary switch that activates blink code diagnostic capabilities. Usually, it is mounted under the instrument panel or on the steering column. Refer to the vehicle specifications for type and location.

   Clearing Fault Codes: The process of erasing faults from the ECU memory bank. Refer to Table B in this section.

   Fault Code: An ABS condition (fault) detected and stored in memory by the Meritor WABCO ECU and displayed by blink code. System faults may be **Active** or **Stored**.

   Active Fault: A condition that currently exists in the ABS system; for example, a sensor circuit malfunction on the left front steering axle. An active fault **must be repaired before you can display additional faults.** Once an active fault has been repaired, it becomes a stored fault.

   Stored Fault: A condition that caused the system to register a fault, but **is not currently active.** For example, a loose wire that corrected itself. A stored fault can also be an active fault that has been corrected. Refer to Active Fault.

   Table B, in this section, describes the method of distinguishing between active and stored faults and explains how to clear them.

   System Code: Displaying identifier for supply voltage (12V) during system mode. Figure 2.7.

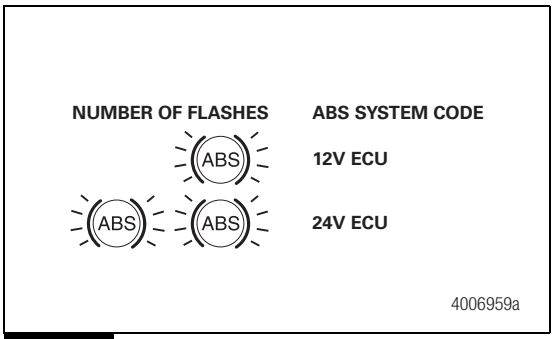


Figure 2.7

Using Blink Code Diagnostics — Optional Feature

Follow the steps listed in Table B to use blink code diagnostics. Refer to Figure 2.15 and Figure 2.16 in this section for blink code illustrations.

1. Wiring Diagram (Figure 2.8)

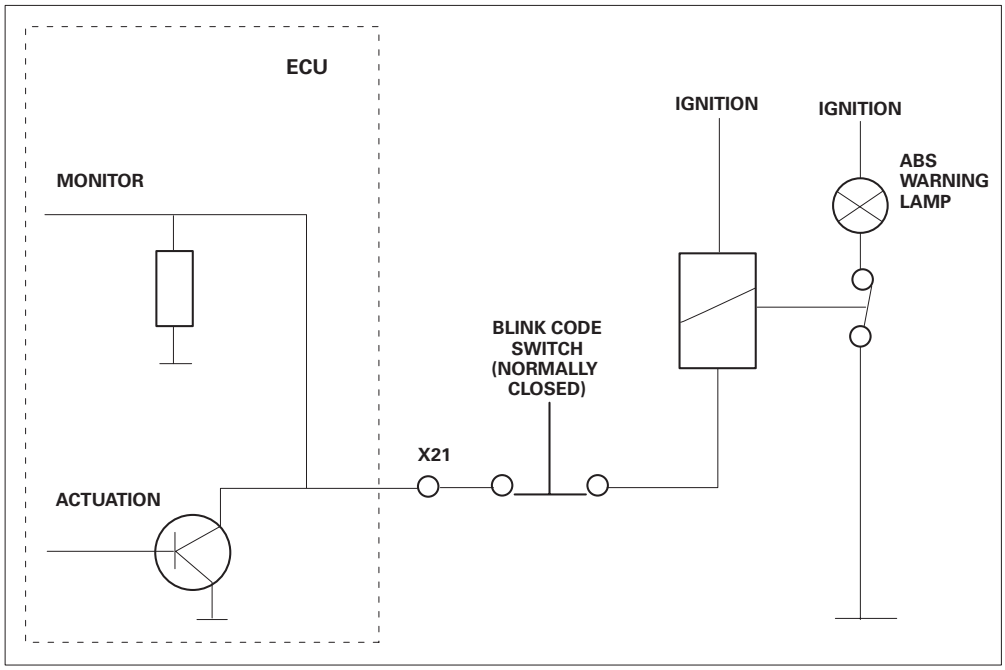


Figure 2.8

2. Activation of Blink Code Function — Optional Feature

   For activation, the blink code switch needs to be actuated for a variable length of time. The duration of the actuation determines the blink code mode. After the switch has been released again, the ABS warning lamp remains illuminated for 0.5 second to indicate the reception of a new blink code command from the user.

3. Termination of Blink Code Function — Optional Feature

   If either a system fault is detected or the blink code switch is depressed for more than 6.3 seconds, the current blink code command will be terminated immediately.

   If the diagnostic mode (output of fault codes via blinking the lamp) has been requested via blink code switch, and if there are no active faults stored inside the ECU (inactive faults only or no faults at all), the blink code is terminated as well after the fault codes have been blinked out once.

   Blink code is terminated if ignition is switched off and if the vehicle starts moving (vehicle speed greater than 2.5 mph or 4 km/h).

   If the blink code switch is held for 15 seconds or longer, an ABS warning lamp fault will be generated which also terminates the blink code.

2 Troubleshooting and Testing

4. Blink Code Frequency (Figure 2.9)

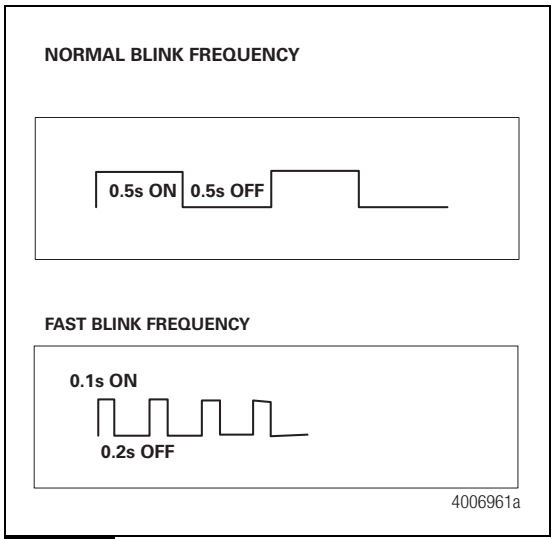


Figure 2.9

5. Diagnostic Mode

   To activate the diagnostic mode, press the blink code switch for more than 0.5 second but less than 3.0 seconds. Figure 2.10.

   With active faults:

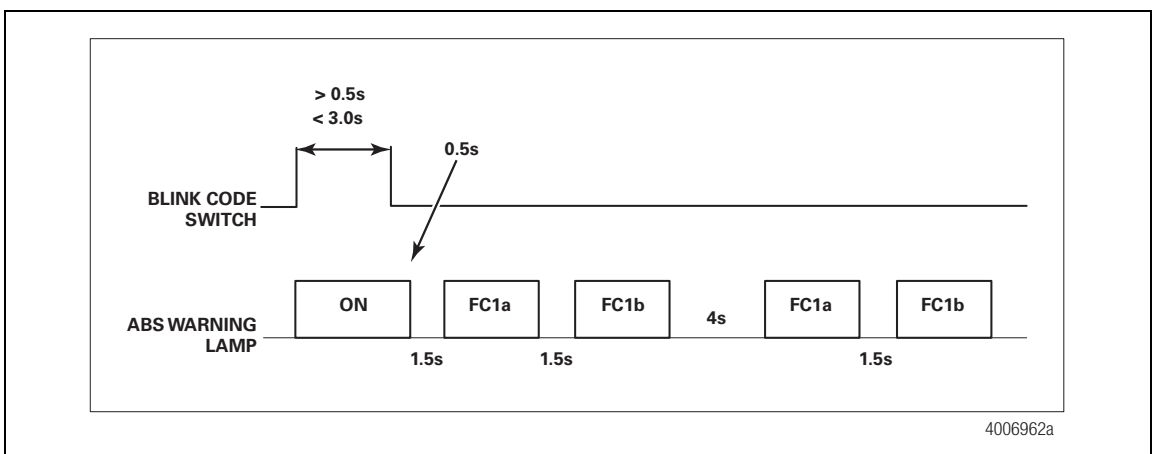


Figure 2.10

2 Troubleshooting and Testing

FC1 is the fault code for the first active fault. ***a*** indicates the first part of the code. ***b*** indicates the second part. Table C.

If a fault was detected during the current ignition switch cycle (an active fault), the corresponding fault code (FC1a and FC1b) is repeated continuously.

If there are several active fault codes, only the most recent is displayed.

The diagnostic mode is terminated if:

- The ignition switch is cycled.
- The vehicle starts moving and its speed exceeds 2.5 mph (4 km/h).
- The blink code switch is actuated for more than 6.3 seconds.

With inactive faults: Figure 2.11.

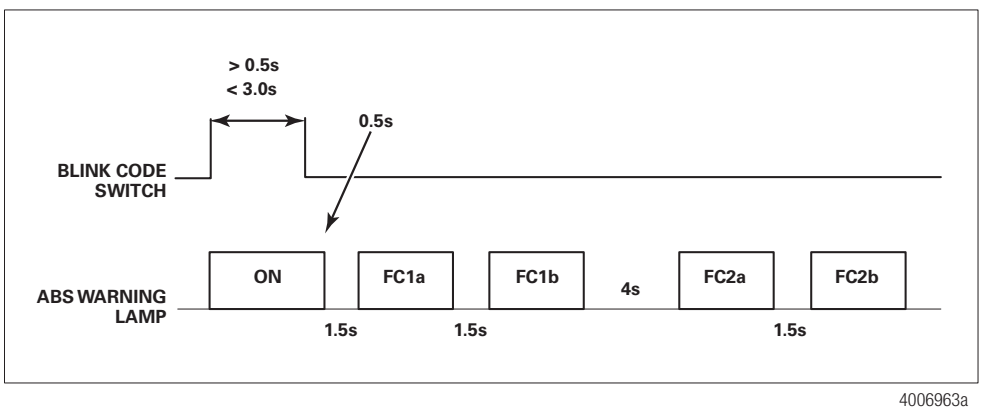


Figure 2.11

FCn is the fault code for an inactive fault. ***a*** indicates the first part of the code. ***b*** indicates the second part. Table C.

If there are no active faults, inactive fault codes will be displayed beginning with the most recent. When all inactive fault codes have been displayed, the diagnostic mode is terminated.

6. Clearing Faults (System) Mode

This mode will be activated if the blink code switch is held for more than 3.0 seconds but less than 6.3 seconds. Within this mode, the faults stored in the ECU will be cleared. After clearing all faults, the ABS warning lamp blinks rapidly eight times. Figure 2.12.

Faults will be cleared only if:

- There is no fault currently active. The system code will be displayed.
- There are air gap faults or pole wheel faults stored in the ecu with an occurrence count of less than 50. If the occurrence count for both air gap and pole wheel faults is more than 50, the ecu is running in ***Sensitive mode*** which prevents fault code clearance. The system code will be displayed.

  NOTE: In ***Sensitive Mode***, modified thresholds increase the speed with which faults are detected.

2 Troubleshooting and Testing

- The maximum on time of the abs inlet valves switches is not exceeded. The maximum on time is 1/3. The system code will be displayed continuously.

  When the faults are cleared, the system code is displayed continuously. Table A.

Table A: System Code

1x	12V ECU AddOn E
2x	24V ECU AddOn E

Two seconds after activating the system mode, endurance brake (retarder) reconfiguration can be requested by pressing the blink code switch three times for at least 0.5 second each at intervals of less than 3.0 seconds.

Completion of reconfiguration will cause the ABS warning lamp to blink rapidly four times.

The system mode will terminate if:

- The ignition switch is cycled.
- The vehicle starts moving and its speed exceeds 2.5 mph (4 km/h).
- The blink code switch is pressed for longer than 6.3 seconds.

All faults will be cleared in system mode only if:

- There are no active faults.
- There are no sensor counts of 50 or greater.
- The maximum inlet valve actuation time was not exceeded.

After clearing all faults, the ABS warning lamp blinks rapidly eight times followed by continuous repetition of the system code. Figure 2.12.

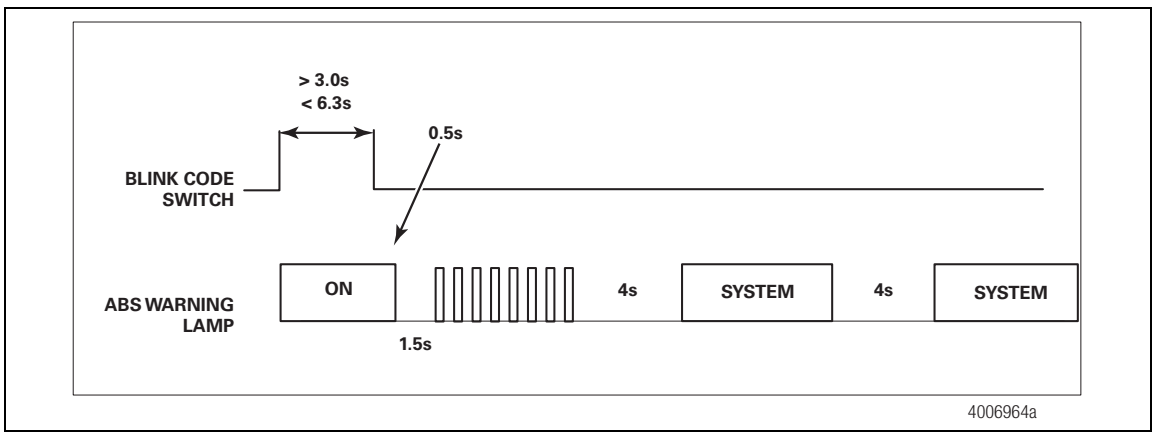


Figure 2.12

2 Troubleshooting and Testing

Faults will not clear if:

- Active faults are detected.
- Stored faults have an occurrence count of 50 or more.
- Maximum inlet valve actuation time is exceeded.

The system code will display continuously. Figure 2.13.

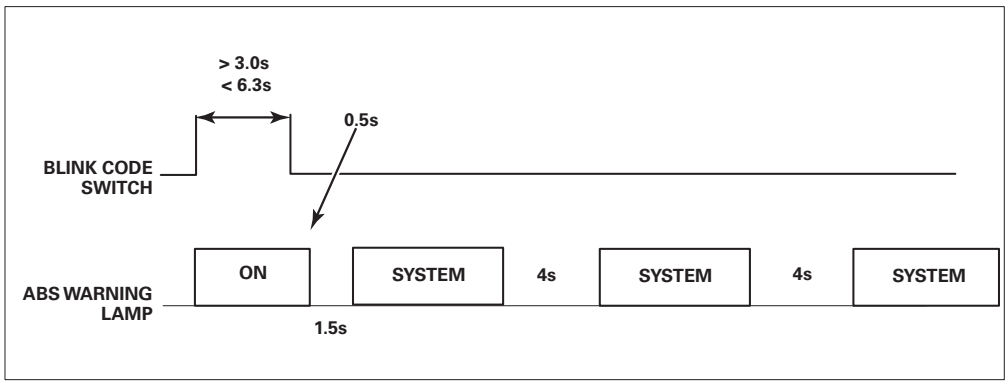


Figure 2.13

7. Retarder Reconfiguration

   Within system mode (after 2.0 seconds), request retarder reconfiguration by pressing the blink code switch three times for at least 0.5 second at intervals of less than 3.0 seconds. Figure 2.14.

   Reconfiguration occurs only if there are no active faults.

   The ABS warning lamp blinks four times to confirm that the retarder has been reconfigured. Then, the system code displays continuously. Figure 2.14.

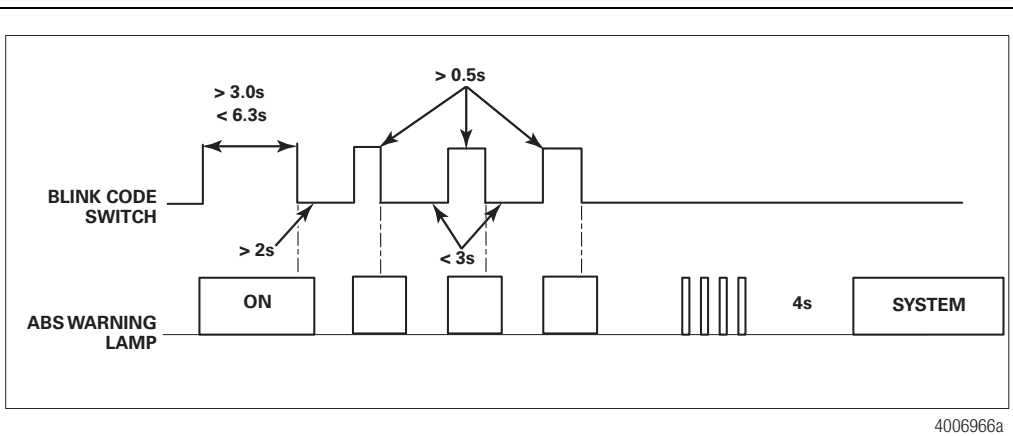


Figure 2.14

2 Troubleshooting and Testing

Table B: Identifying E Version Hydraulic ABS Blink Codes

Troubleshooting with Blink Code Diagnostics — Optional Feature			
Mode	**Procedure**	**System Response**	**Action**
Diagnostics	**Step I.** Turn ignition ON.	Possible responses:	
		1. ABS warning lamp comes on momentarily then goes out, indicating System O.K.	No recognizable active faults in the ABS. No action required.
		2. ABS warning lamp does not light, indicating possible wiring fault or burned-out bulb.	Inspect wiring. Inspect bulb. Make the necessary repairs.
		3. ABS warning lamp stays on, indicating:	
		• Fault, or faults, in the system	Continue with blink code diagnostics. Go to Step II.
		• Sensor fault during last operation	Continue with blink code diagnostics. Go to Step II.
		• Faults cleared from ECU, but vehicle not driven.	Drive vehicle — lamp will go out when vehicle reaches four mph (6 km/h).
		• ECU disconnected.	Connect ECU.
	Step II. Press and hold Blink Code Switch for one second, then release.	ABS warning lamp begins flashing two-digit blink code(s).	Determine if fault is active or stored: **Active Fault:** Lamp will repeatedly display one code. **Stored Fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only**.
	Step III. Count the flashes to determine the blink code.	First Digit: 1-14 flashes, Pause (1-1/2 seconds). Second Digit: 1-11 flashes, Pause (4 seconds).	Find definition for blink code on blink code chart.
	Step IV. Turn ignition OFF. Repair and record faults	Active Fault.	Make the necessary repairs.
		Stored Faults.	Record for future reference.
Clear	**Step V.** Turn ignition ON. Clear faults from memory: **Press and hold** blink code switch for 3.0 to 6.0 seconds, then release.	ABS warning lamp flashes eight times.	All stored faults successfully cleared. Turn ignition OFF. Turn ignition ON. The warning lamp will stay on. This is because the ECU is looking for wheel speed. Drive the vehicle at a speed of four mph (6 km/h). Once the ECU senses wheel speed, the lamp will go off.
		Eight flashes not received.	Active faults still exist, repeat Step I through Step V.

Blink Codes Illustrated

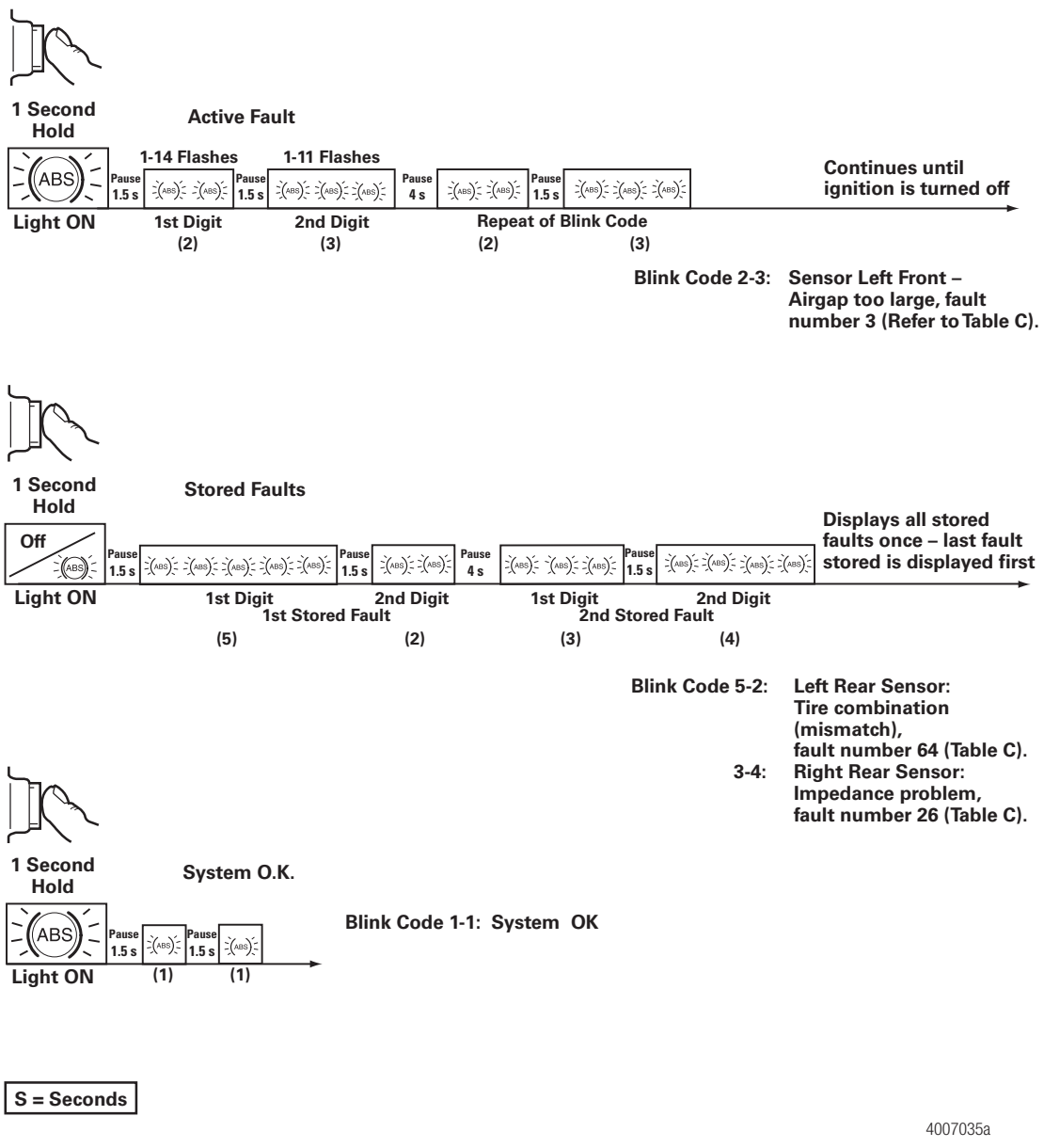


Figure 2.15

2 Troubleshooting and Testing

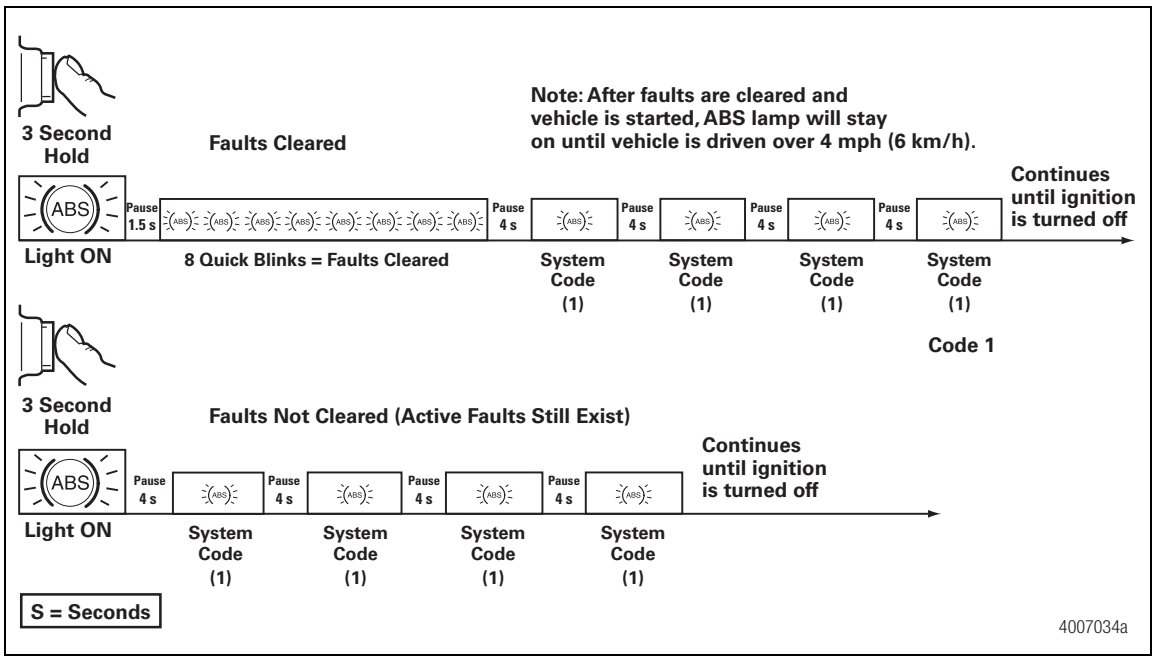


Figure 2.16

E Version Hydraulic ABS Blink Codes

Use the information in Table C to identify a fault and its fault number.

The blink code appears in two parts. The first part identifies the faulty component. The second part identifies the location or the description of the fault.

1. Identify and record the blink code. Blink codes are identified in Columns **1** and **2**.
2. Find the fault number in Column **3**.

Table C: E Version Blink Codes

First Part	Second Part	Fault Number
1 No Failure	1 No Failure	—
2 Sensor: Air gap	1 Right Front	1
2 Sensor: Air gap	2 Left Rear	2
2 Sensor: Air gap	3 Left Front	3
2 Sensor: Air gap	4 Right Rear	4
3 Sensor: Impedance	1 Right Front	23
3 Sensor: Impedance	2 Left Rear	24
3 Sensor: Impedance	3 Left Front	25

2 Troubleshooting and Testing

Table C: E Version Blink Codes

First Part	Second Part	Fault Number
3 Sensor: Impedance	4 Right Rear	26
4 Sensor: No trigger at all	1 Right Front	73
4 Sensor: No trigger at all	2 Left Rear	74
4 Sensor: No trigger at all	3 Left Front	75
4 Sensor: No trigger at all	4 Right Rear	76
5 Sensor: Tire Combination	1 Right Front	63
5 Sensor: Tire Combination	2 Left Rear	64
5 Sensor: Tire Combination	3 Left Front	65
5 Sensor: Tire Combination	4 Right Rear	66
6 Power Amplifier: Short to Ubat/Uvent	1 Right Front Inlet Valve	9
6 Power Amplifier: Short to Ubat/Uvent	2 Right Front Outlet Valve	10
6 Power Amplifier: Short to Ubat/Uvent	3 Left Front Inlet Valve	11
6 Power Amplifier: Short to Ubat/Uvent	4 Left Front Outlet Valve	12
6 Power Amplifier: Short to Ubat/Uvent	5 Right Rear Inlet Valve	13
6 Power Amplifier: Short to Ubat/Uvent	6 Right Rear Outlet Valve	14
6 Power Amplifier: Short to Ubat/Uvent	7 Left Rear Inlet Valve	15
6 Power Amplifier: Short to Ubat/Uvent	8 Left Rear Outlet Valve	16
6 Power Amplifier: Short to Ubat/Uvent	9 Engine Brake Relay	17
6 Power Amplifier: Short to Ubat/Uvent	10 Brake Light Relay	18
7 Power Amplifier: Open Circuit	1 Right Front Inlet Valve	27
7 Power Amplifier: Open Circuit	2 Right Front Outlet Valve	28
7 Power Amplifier: Open Circuit	3 Left Front Inlet Valve	29
7 Power Amplifier: Open Circuit	4 Left Front Outlet Valve	30
7 Power Amplifier: Open Circuit	5 Right Rear Inlet Valve	31
7 Power Amplifier: Open Circuit	6 Right Rear Outlet Valve	32
7 Power Amplifier: Open Circuit	7 Left Rear Inlet Valve	33
7 Power Amplifier: Open Circuit	8 Left Rear Outlet Valve	34
7 Power Amplifier: Open Circuit	9 Engine Brake Relay	35
7 Power Amplifier: Open Circuit	10 Brake Light Relay	36
8 Power Amplifier: Short to Ground	1 Right Front Inlet Valve	41
8 Power Amplifier: Short to Ground	2 Right Front Outlet Valve	42
8 Power Amplifier: Short to Ground	3 Left Front Inlet Valve	43
8 Power Amplifier: Short to Ground	4 Left Front Outlet Valve	44
8 Power Amplifier: Short to Ground	5 Right Rear Inlet Valve	45
8 Power Amplifier: Short to Ground	6 Right Rear Outlet Valve	46
8 Power Amplifier: Short to Ground	7 Left Rear Inlet Valve	47

2 Troubleshooting and Testing

Table C: E Version Blink Codes

First Part	Second Part	Fault Number
8 Power Amplifier: Short to Ground	8 Left Rear Outlet Valve	48
8 Power Amplifier: Short to Ground	9 Engine Brake Relay	49
8 Power Amplifier: Short to Ground	10 Brake Light Relay	50
9 Inlet Valve Actuation Time	1 Right Front	80
9 Inlet Valve Actuation Time	2 Left Rear	81
9 Inlet Valve Actuation Time	3 Left Front	82
9 Inlet Valve Actuation Time	4 Right Rear	83
10 Pump Motor	1 pm monitor voltage unexp. high	67
10 Pump Motor	2 pm monitor voltage unexp. low	68
10 Pump Motor	3 motor does not turn	69
10 Pump Motor	4 no pm supply voltage	70
10 Pump Motor	5 pm relay does not switch on	71
10 Pump Motor	6 pm relay does not switch off	72
11 J1939	1 Internal	77
11 J1939	2 bus failure	78
11 J1939	3 message failure	79
12 Pole Wheel	1 Right Front	84
12 Pole Wheel	2 Left Rear	85
12 Pole Wheel	3 Left Front	86
12 Pole Wheel	4 Right Rear	87
13 Brake Chatter	1 Right Front	90
13 Brake Chatter	2 Left Rear	91
13 Brake Chatter	3 Left Front	92
13 Brake Chatter	4 Right Rear	93
14 System	1 valve relay can't switch off	55
14 System	2 valve relay can't switch on	56
14 System	3 reference ground connection	57
14 System	4 tire parameter not correct	58
14 System	5 ABS warning light bulb	59
14 System	6 brake warning light bulb	60
14 System	7 High Voltage	61
14 System	8 Low Voltage	62
14 System	9 Clamp	88
14 System	10 Pull Up Down	89
14 System	11 Internal Error	0

2 Troubleshooting and Testing

Testing the System

This section of the manual contains information for testing the hydraulic ABS with TOOLBOX™ Software, as well as procedures for conducting standard air and electrical tests.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Exhaust gas contains poison. When testing a vehicle with the engine running, test in a well-ventilated area or route the exhaust hose outside.

To avoid serious personal injury, keep away, and keep test equipment away, from all moving or hot engine parts.

Refer to, and follow, the vehicle manufacturer's Warnings, Cautions and Service Procedures.

When testing, set the parking brake and place the gear selector in NEUTRAL (manual transmission) or PARK (automatic transmission) unless otherwise directed.

Meritor WABCO TOOLBOX™ Software

Use TOOLBOX™ Software to verify the activation of various system components:

- Turn valves, pump and retarder relay on and off (Valve Activation Menu).
- Turn ABS warning lamp on and off (Miscellaneous Output Activation Menu).

NOTE: TOOLBOX™ Software must be connected to the vehicle and the vehicle ignition must be ON in order to display information.

NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX™ Software.

E Version Hydraulic ABS Menus and Toolbars

Select Hydraulic ABS from the TOOLBOX™ ***Main Menu***. TOOLBOX™ senses the type of ECU being used and displays the ***HABS Main Screen***.

Main Screen

This screen provides icons and pull-down menu task selections. It also provides information about the current status of Meritor WABCO HABS. Figure 2.17.

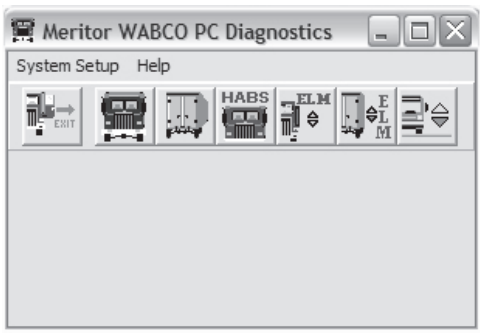


Figure 2.17

ECU information is read once from the ECU and does not change. All other information (e.g., wheel sensors, voltages and fault information) is read and updated continuously.

Display

Select ***Display*** from the HABS ***Main Screen***. A pull-down menu will appear. Figure 2.18.

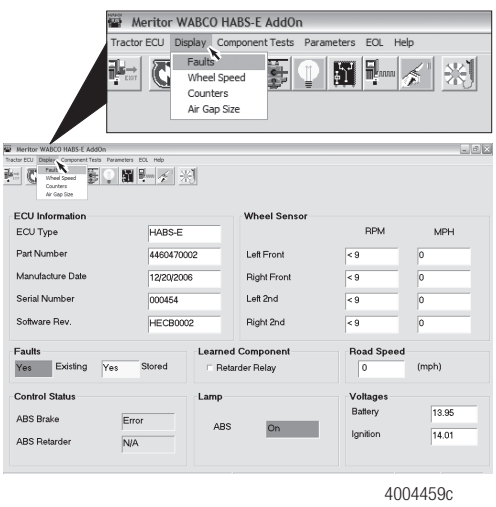
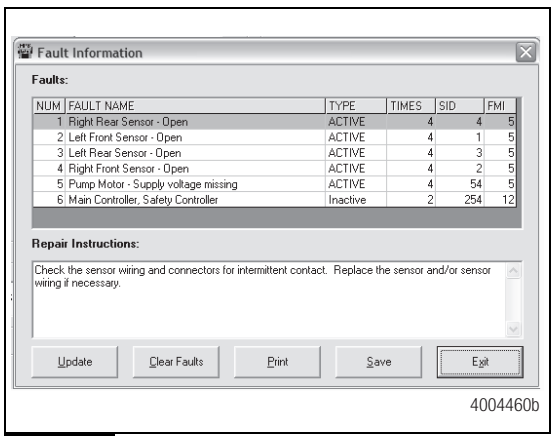


Figure 2.18

2 Troubleshooting and Testing

Faults

Select ***Faults*** to display the ***Fault Information*** screen. Figure 2.19.



4004460b

Figure 2.19

The ***Fault Information*** screen contains a description of each fault, including the type of fault (Active or Stored), number of occurrences, SID and FMI number. Repair instructions for the fault appear at the bottom of the screen.

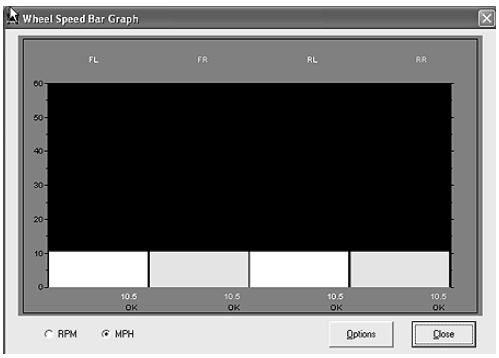
Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the ***Update*** button at the bottom of the screen to refresh the fault information table and display a new list of faults.

After making any required repairs, use the ***Clear Faults*** button to clear the fault. Clear each fault as it is repaired. Cycle the ignition after clearing the faults.

Use the ***Save*** or ***Print*** button to save or print the fault information data. Select ***Exit*** to close this section.

Wheel Speed

Select ***Wheel Speed*** to display the ***Wheel Speed*** screen. Figure 2.20.



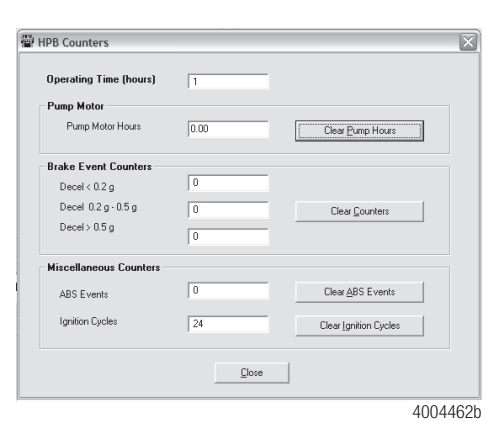
4004461a

Figure 2.20

Use the ***Wheel Speed*** screen to verify that sensors are connected at each wheel. Speed at a sensed wheel (FL, FR, RL, RR) indicates sensors are installed, but does not verify correct sensor installation.

Counters

Select ***Counters*** to display the ***Counters*** screen. Figure 2.21.



4004462b

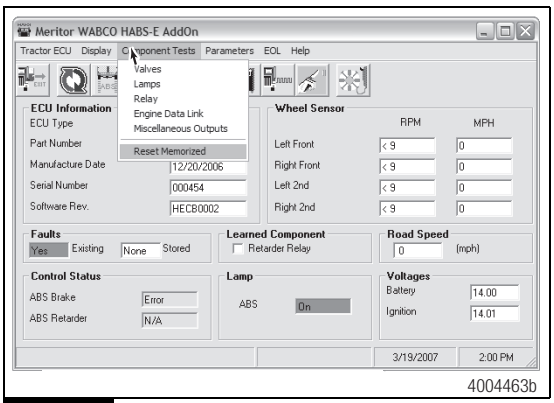
Figure 2.21

The ***Counters*** screen provides an overview of HABS component performance (pump hours, brake events, etc.) as well as general vehicle activity such as ignition cycles. Occurrences displayed on this screen accumulate until the ***Clear*** button is selected.

2 Troubleshooting and Testing

Component Tests

Select ***Component Tests*** from the HABS ***Main Screen***. A pull-down menu will appear. Figure 2.22.



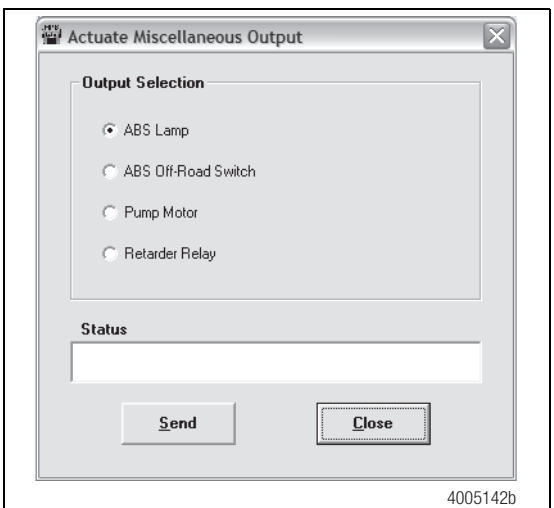
4004463b

Figure 2.22

Miscellaneous Outputs

Select ***Miscellaneous Outputs*** to display the ***Actuate Miscellaneous Outputs*** test screen. Figure 2.23.

NOTE: Use TOOLBOX™ Software to test the following components: Retarder Relay, Brake Light Relay, Supply Valve, Cut-Off Valve, ABS Lamp, Traction Lamp, Brake Warning, Pump Front, Pump Rear, Buzzer.



4005142b

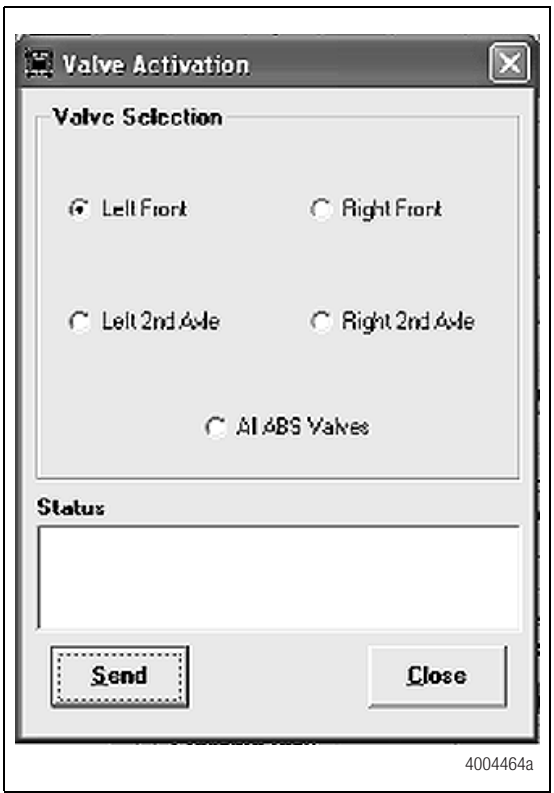
Figure 2.23

This screen provides a check of several HABS components, as well as a way to check either inlet or outlet activity of the valves, pump or retarder relay.

Highlight the component you wish to test, then select the ***Send*** button to actuate the component. Component activation status appears in the ***Status Box*** field. Select ***Close*** to exit this screen.

Valves

Select ***Valves*** to display the ***Valve Activation*** test screen. Figure 2.24.



4004464a

Figure 2.24

The ***Valve Activation*** test screen lets you activate the HABS valves to check for correct activation and to verify correct brake line installation.

Click on the valve you wish to test, then click the ***Send*** button to actuate the component. Component activation status appears in the ***Status*** box field. Select ***Close*** to exit this screen.

2 Troubleshooting and Testing

Lamps

Select ***Lamps*** to display the ***Lamp Test*** screen. Figure 2.25.

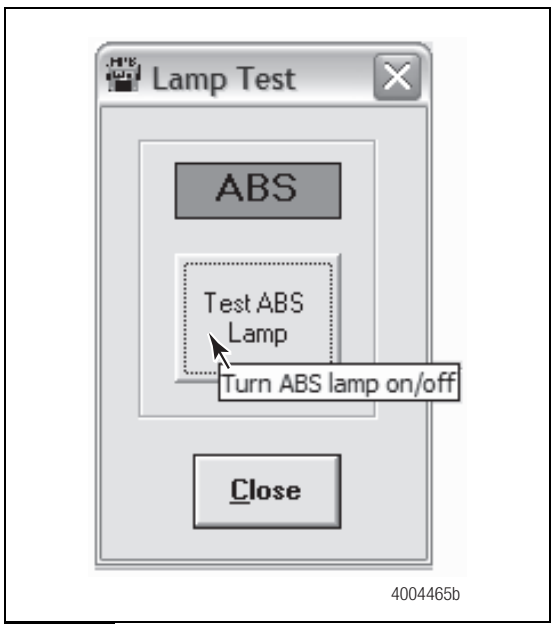


Figure 2.25

As each lamp is tested, check the actual lamp to verify correct operation. Select ***Close*** to exit this screen.

Relay

Select ***Relay*** to display the ***Activate Relay*** test screen. Figure 2.26.

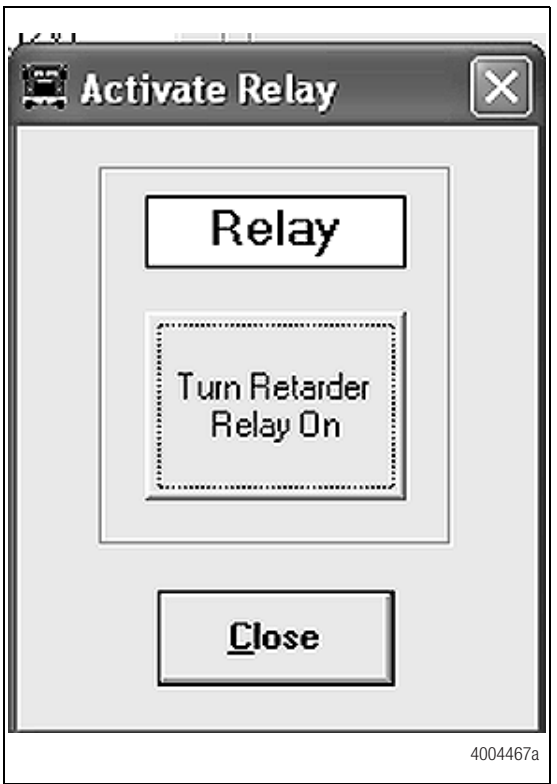


Figure 2.26

This screen allows you to turn the retarder relay on or off. This is helpful in verifying correct operation, installation and wiring of the unit under test. Select ***Close*** to exit this screen.

Engine Data Link

Select ***Engine Data Link*** to display the ***Data Link*** test screen. Figure 2.27.

2 Troubleshooting and Testing

Figure 2.27

This screen allows you to send a "limit engine torque" command to the engine or a "disable retarder" command to the retarder.

Select the data link destination (engine or retarder), then select ***Send*** to test. Use the ***Stop*** button to end testing. Select ***Close*** to exit this screen.

Reset Memorized

This is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up. Figure 2.28.

Because there are times when an ECU is moved to another vehicle — or during diagnostic testing — you may want the ECU to disregard this learned component. Use the ***Reset Memorized*** command for this purpose.

Select ***Component Tests*** from the Hydraulic ABS ***Main Menu***. Then, select ***Reset Memorized*** from the pull-down menu to reset the ***Learned Component*** screen. Figure 2.29.

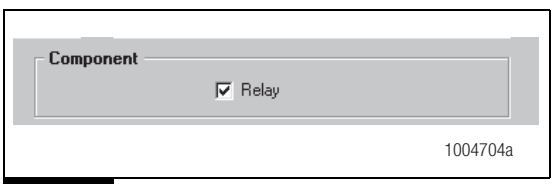


Figure 2.28

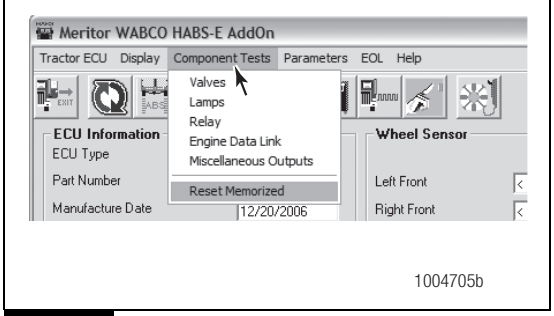


Figure 2.29

Standard Testing

Test Equipment: Volt-Ohm Meter (VOM)

Use of a VOM with automatic polarity sensing is recommended. This eliminates the concern of the polarity of the meter leads during voltage measurements.

System Requirements and Component Tests

Tire Size Range

For correct hydraulic ABS operation, front and rear tire sizes must be within 16% of each other.

Contact the Meritor WABCO Customer Support Center at 800-535-5560 if you plan a tire size difference greater than 8%.

Calculate the tire size with the following equation:

% Difference = (RPM Steer/RPM Drive) –1 x 100

RPM = tire revolutions per mile

2 Troubleshooting and Testing

⚠ CAUTION

When troubleshooting or testing the ABS system, do not damage the connector terminals. Damaged connector terminals may cause system malfunction.

Voltage Check

Voltage must be between 9.5 and 14 volts for the 12-volt hydraulic ABS to function correctly.

Check voltage as follows.

1. Turn ignition ON.
2. Check for the correct voltage.
   - Pins 16 to 18
   - Pins 17 to 19
   - Pins 1 to 6

Standard Component Testing

ABS Warning Lamp

If the ABS warning lamp does not come on after the ignition is turned on, or it comes on but does not go out after three seconds, check all ABS fuses or circuit breakers and replace if necessary. Check the wiring to the ABS diagnostic switch and the warning lamp and repair or replace the wiring as required. When checking the warning lamp, follow these steps:

1. Check voltage potential at the lamp socket.
2. Check continuity of the wires to the socket.
3. Replace the bulb.

NOTE: A complete wiring diagram for 4S/4M D Version hydraulic ABS appears in Figure 2.2 in this section.

ABS Blink Code Switch

When testing the ABS diagnostic switch, perform the following.

1. Check the resistance between the terminals while cycling the switch. A lack of continuity is an indication of a faulty switch.
2. Check the continuity of the wires to the switch:

   Pins 21 and 6 on the 31-pin harness

Sensor Adjustment

On steering axles, the sensor is typically accessible on the in-board side of the steering knuckle.

On drive axles, the sensor is typically accessible on the in-board side of the rear axle spindle.

To adjust the sensor, push the sensor in until it contacts the tooth wheel.

- Do not pry or push sensors with sharp objects.
- Sensors will self-adjust during wheel rotation.

NOTE: No gap is allowable at installation. During normal operation, a gap not to exceed 0.04-inch is allowable.

Sensor Output Voltage Test

Sensor output voltage must be at least 0.2 volt AC at 30 rpm. Test the sensor output voltage as follows:

1. Turn ignition OFF.
2. Disconnect the ECU to measure voltage at the pins on the ECU connector. Refer to Table D.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

3. Place blocks under the front and rear tires to stop the vehicle from moving.
4. Raise the vehicle off the ground. Place safety stands under the axle.
5. Rotate the wheel by hand at 30 rpm (1/2 revolution per second).
6. Measure the voltage at the pins indicated in Table D. Voltage tolerance is ≥0.2 volts alternating current (VAC).

Table D: Sensor Check Pins

	HABS E Version ECU
Sensor	**31-Pin Harness**
Left Front	24 and 29
Right Front	25 and 30
Left Rear	23 and 28
Right Rear	22 and 27

Sensor Resistance

The sensor circuit resistance must be between 900 and 2000 ohms. Measure resistance at the sensor connector, or at the pins on the ECU connector, as follows.

1. Turn ignition OFF.
2. To measure resistance at the pins on ECU connector, disconnect the ECU connector from the ECU.

   To measure resistance at the sensor connector, disconnect the sensor from the sensor extension cable.
3. Measure output at the pins indicated in Table D.

   If measurement is not between 900 and 2000 ohms, replace the sensor.

3 Component Replacement

Component Removal and Installation

Sensors

Sensor Lube Specification

Meritor WABCO specifications call for a sensor lubricant with the following characteristics.

Lube must be mineral oil-based and contain molydisulfide. It should have excellent anti-corrosion and adhesion characteristics and be capable of continuous function in a temperature range of –40° to 300°F (–40° to 150°C).

Meritor WABCO provides sensor lube in a packet with each sensor service part.

Wheel Speed Sensor Replacement — Front Axle

Removal

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

⚠ CAUTION

To avoid damage to the electrical system or HABS components, when welding on a HABS-equipped vehicle disconnect the power connector from the ECU.

1. Park the vehicle on a level surface. Apply the parking brakes. Block the rear tires to prevent the vehicle from moving.

   If necessary, raise the front tires off the ground. Place safety stands under the axle.
2. Disconnect the fasteners that hold the sensor cable to other components.
3. Disconnect the sensor cable from the chassis harness.
4. Remove the sensor from the sensor holder. Twist and pull the sensor to remove it from the sensor bracket. **Do not pull on the cable. Figure 3.1.**

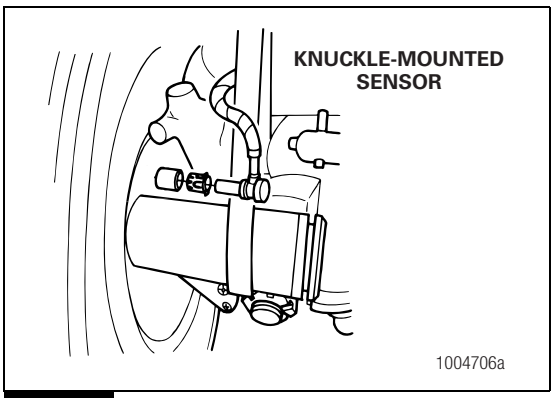


Figure 3.1

Installation

1. Connect the sensor cable to the chassis harness.
2. Install the fasteners used to hold the sensor cable in place.
3. Apply a Meritor WABCO-recommended lubricant to the sensor spring clip and sensor.
4. Install the sensor spring clip. Verify that the spring clip tabs are on the inboard side of the vehicle.
5. With the tabs on the inboard side, push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.
7. Fasten the sensor cable every 12 inches. Correctly bundle and store any excess cable in the sub-frame. Figure 3.1.
8. Remove the blocks and safety stands.
9. Perform a voltage output check to ensure correct installation. Refer to Section 2.

Wheel Speed Sensor Replacement — Rear Axle

Removal

1. Apply the parking brake. Block the front tires to prevent vehicle movement.
2. Raise the rear tires off the ground. Place safety stands under the axle.
3. If the rear tire must be removed to gain access to the sensor, release the parking brake to release the brake shoe.

   Remove the wheel and tire assembly from the axle.

3 Component Replacement

4. Remove the sensor from the mounting block. Use a twisting motion if necessary. **Do not pull on the cable.**
5. Disconnect the sensor cable from the chassis harness.
6. Remove the sensor cable from any cable clamps or clips.
7. Remove the sensor spring clip from the sensor bracket.

Installation

1. Connect the new sensor cable to the chassis harness.
2. Press the sensor spring clip into the sensor bracket, located on the rear axle, until it stops. Verify that the tabs are on the inboard side.
3. Apply a Meritor WABCO-recommended lubricant to the sensor.
4. Push the sensor completely into the spring clip until it contacts the tooth wheel.
5. Reattach the sensor cable to the cable clamps or clips.
6. Fasten the sensor cable every 12 inches. Correctly bundle and store excess cable in the sub-frame. Figure 3.2.

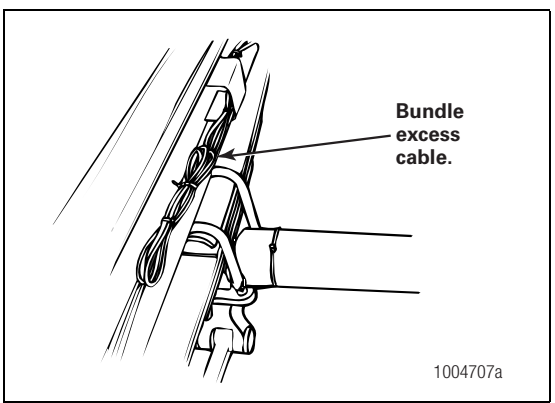


Figure 3.2

7. Replace the tire and remove the safety stands. Lower the vehicle and remove the blocks from the front tires.
8. Perform a voltage output check to ensure correct installation. Refer to Section 2.

Electronic Control Unit (ECU)

Removal

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

⚠ CAUTION

Hydraulic brake fluid is a caustic substance. Contact with the hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid contact brake pads, shoes, rotors or discs.

NOTE: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

NOTE: The following general guidelines are provided to facilitate the safe removal of the ECU module from the modulator assembly.

- It is not necessary to remove the entire modulator to replace the Electronic Control Unit (ECU).
- When only the ECU is replaced, bleeding the system is not necessary.

1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
2. Block the front and rear tires to prevent vehicle movement.
3. Disconnect the battery.
4. Use a clean rag to carefully wipe the surface of the modulator and the surrounding area.
5. Open the latches on the 31-pin harness attached to the ECU. After the latch is released, remove the connectors from the ECU.
6. Use a 4 mm Allen wrench to loosen and remove the four mounting screws that attach the ECU module to the modulator valve.
7. Carefully remove the ECU by lifting straight out. To avoid damage, do not twist the ECU during removal. Determine the warranty status of the ECU. If the ECU is under warranty, return it to Meritor WABCO. If it is not under warranty, discard the used ECU.
8. Use a clean rag to carefully clean the area around the valves formerly covered by the ECU.

3 Component Replacement

Installation

⚠ CAUTION

Excessive force in positioning the ECU onto the modulator will damage the ECU housing. Do not force the ECU into position. Use a gentle, even pressure when positioning the ECU.

1. Position the ECU onto the modulator valve. Apply gentle pressure to seat the ECU. Motor connectors must achieve full depth into the housing. The gap between the modulator and ECU must not exceed 0.08-inch (2 mm).
2. Use a 4 mm Allen wrench to tighten the four mounting screws that attach the ECU to the modulator. Tighten to 14 in-lb (1.5 N•m). Do not exceed this torque. The metal sleeves on the ECU housing must rest flat on the body of the modulator. ⓣ
3. When the ECU is correctly installed with the metal sleeves flat on the modulator, tighten the bolts to 21-30 in-lb (2.5-3.5 N•m). ⓣ

⚠ WARNING

Electrical connectors must be correctly installed with the latch pushed in to lock the connector. Failure to do so may allow the connectors to come loose or disconnect resulting in loss of ABS function.

4. Attach the 31-pin harness connector to the ECU.
5. Connect the battery.

Modulator Assembly

Removal

⚠ CAUTION

The modulator assembly contains hydraulic brake fluid, a caustic substance. Remove the valve carefully so that fluid does not leak and cause skin irritation or damage to components.

NOTE: If there is interference, the entire bracket and valve assembly can be removed.

1. Apply the parking brakes. Block the front and rear tires to prevent vehicle movement.
2. Place a container under the modulator assembly to catch leaking brake fluid.
3. Disconnect the electrical harness connectors from the modulator assembly.
4. Mark the six brake lines for ease of installation. Disconnect the lines from the modulator assembly.
5. Remove the three mounting capscrews and washers that attach the modulator assembly to the bracket.

   NOTE: Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered. Refer to "Brake Bleeding Procedures" in this section.

6. Remove the modulator assembly.

Installation

1. Position the modulator assembly in place on the vehicle. Figure 3.3.

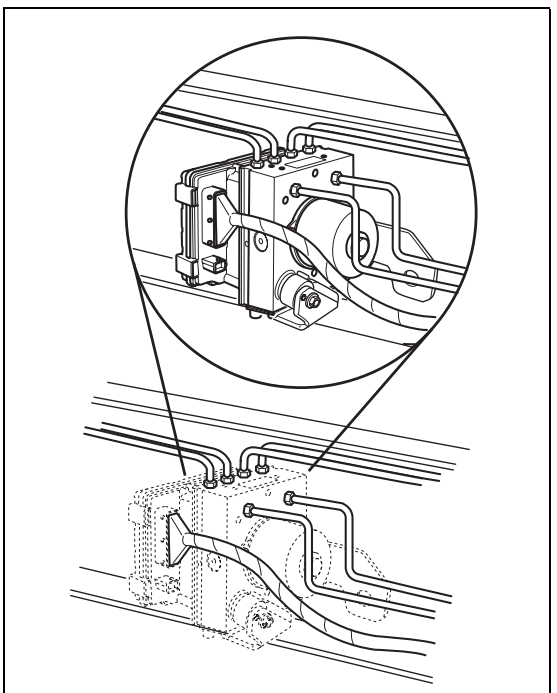


Figure 3.3

2. Tighten the three mounting nuts to 16 ft-lb (22 N•m). ⓣ
3. Connect the electrical harnesses to the modulator assembly.

4. Connect and tighten the brake line connections.
5. Bleed the brake system, per the following instructions.

Brake Bleeding Procedures

General

The following brake bleeding methods explain how to bleed the hydraulic ABS modulator assembly during installation, or in the event of air in the brake system. There are instructions for both pressure and manual bleeding procedures.

These instructions include the procedure for bleeding both the master cylinder and the brake system. In some cases, for example, if you are replacing only the modulator assembly, it may not be necessary to bleed the master cylinder. If you have any questions, please contact the Meritor Service Center at 800-535-5560.

NOTE: The modulator assembly must be handled with appropriate care and should not be exposed to excessive impact or compressed air at the hydraulic ports prior to assembly.

⚠ WARNING

Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will prevent the hydraulic pressure in the brake system from rising enough to apply the brakes correctly. This will cause the stopping distance to increase and can result in serious personal injury.

Correctly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and can cause damage, loss of braking and serious personal injury.

Use only the type of hydraulic brake fluid specified by the equipment manufacturer. Do not use or mix different types of hydraulic brake fluid. The wrong hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

NOTE: Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.

⚠ CAUTION

Hydraulic brake fluid is a caustic substance. Contact with hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads, shoes, rotors or discs.

Pressure Fill and Bleed

Pressure fill and bleed is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These kits are available from a number of manufacturers and include instructions for use. Figure 3.4.

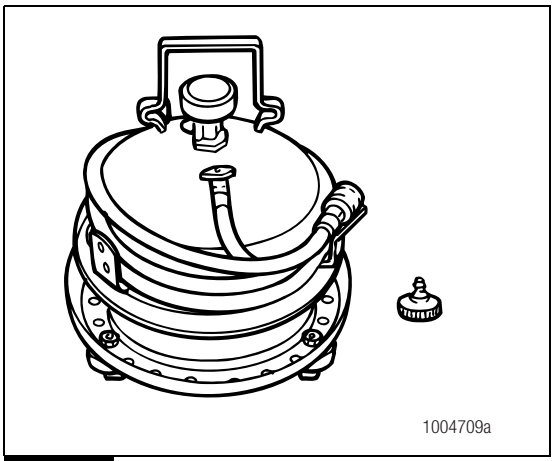


Figure 3.4

Pressure Fill and Bleed Procedure

⚠ CAUTION

Turn the ignition OFF for the entire bleed procedure. Do not energize the unit during the bleed procedure. Improper bleeding may result in system malfunction due to the presence of air in the closed hydraulic system.

1. Apply the parking brake and block the tires. Turn the ignition OFF and disconnect the battery terminals.
2. Fill the pressure bleeder with new DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.

3 Component Replacement

3. Follow the manufacturer's instructions to connect the pressure bleeder to the brake master cylinder reservoir.
4. Set the filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
5. Turn on the bleed equipment until the fluid level in the reservoir reaches approximately 0.875-inches (20 mm).
6. Release pressure for three to five seconds. Apply pressure for five to 10 seconds.
7. Repeat Step 5 and Step 6 approximately 10 times. After releasing the pressure, air bubbles should rise up into the reservoir.

⚠ WARNING

Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-approved brake fluid, as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering the system, making it impossible to effectively bleed the system resulting in increased stopping distance.

8. Bleed the brake system:
   - Set the filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
   - Place a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, typically the right rear, then attach a length of clear plastic tubing to the bleeder fitting. Verify that the tube fits snugly.

   NOTE: Both the tubing and container must be able to withstand the effects of hydraulic brake fluid. Tools used for bleeding the system should be brake fluid-safe.

9. Submerge the tubing in a container of clean hydraulic brake fluid. Figure 3.5.

   Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn). Let the hydraulic fluid flow out of the fitting until it is free of air bubbles.

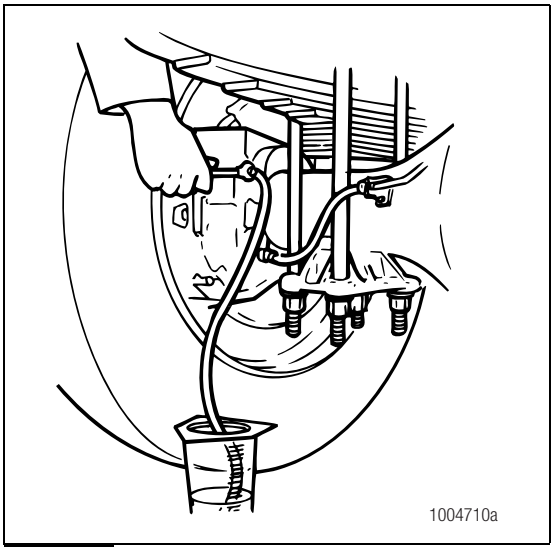


Figure 3.5

10. Tighten firmly to secure the fitting.
11. Repeat Step 5 through Step 8 to bleed the remaining three brake actuators. Bleed in sequence of the longest to shortest circuit from the modulator assembly.
12. Turn off bleed equipment and remove pressure. Remove the bleed device and check the fluid level in the reservoir. Fill if required. Replace the reservoir cap and dispose of used brake fluid.
13. Remove the wheel blocks.

Manual Bleed Procedure

NOTE: The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.

1. Apply the parking brake and block the tires. Turn the ignition OFF and disconnect the battery terminals.
2. Fill the reservoir with DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.
3. Depress the brake pedal five times using the stroke between 1/3 travel and maximum travel in five seconds.
4. Release the pedal for five to 10 seconds. Air bubbles will rise into the reservoir while depressing and releasing the pedal.

5. Repeat Step 3 and Step 4 another three times, or until sufficient pedal resistance is felt.

⚠ WARNING

Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-approved brake fluid as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering the system, making it impossible to effectively bleed the system resulting in increased stopping distance.

6. Bleed the brake system. Place a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Verify that the tube fits snugly.

   NOTE: Both the tubing and container must be able to withstand the effects of brake fluid. Tools used for bleeding the system should be brake fluid-safe.

7. Submerge the tubing in a container of clean brake fluid. Figure 3.5.
8. Depress the brake pedal 10 to 15 times, using the maximum available stroke.
9. Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn), while depressing the brake pedal through its maximum available stroke.
10. Tighten the fitting firmly prior to releasing the brake pedal.
11. Repeat Step 6 through Step 8 several times until the discharged fluid is free of air bubbles.
12. Repeat Step 3 through Step 9 to bleed the remaining three brake actuators. Bleed in sequence of the longest to the shortest circuit from the modulator.
13. Check the travel of the brake pedal. If a firm resistance is felt, the manual bleeding procedure is complete.
14. Check the fluid level in the reservoir and fill if required. Replace the reservoir cap and dispose of used brake fluid.
15. Remove the wheel blocks.

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ArvinMeritor, Inc.

Printed in USA
Revised 10-08
Maintenance Manual MM-0677 (16579/22882)

MERITOR WABCO

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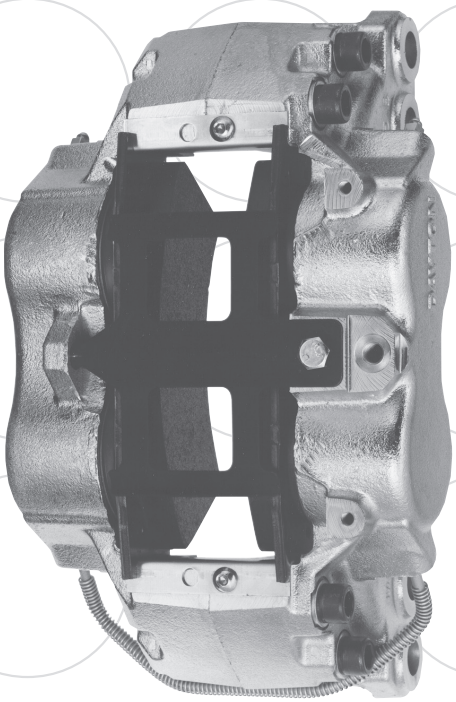
Maintenance Manual MM-2075

Four-Piston Quadraulic™ Disc Brake Caliper

Revised 08-09



Service Notes

About This Manual

This manual provides instructions for Meritor four-piston Quadraulic™ disc brake calipers.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at arvinmeritor.com to access and order product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components.

Literature on Demand DVD (LODonDVD)

The LODonDVD contains product, service and warranty information for ArvinMeritor components. To order the DVD, visit Literature on Demand at arvinmeritor.com and specify TP-0742.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

Information contained in this publication was in effect at the time the publication was approved for printing and is subject to change without notice or liability. Meritor Heavy Vehicle Systems, LLC, reserves the right to revise the information presented or to discontinue the production of parts described at any time.

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Asbestos and Non-Asbestos Fibers

⚠ ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

2. Respiratory Protection. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up**.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

⚠ NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. Respiratory Protection. OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m^3 as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

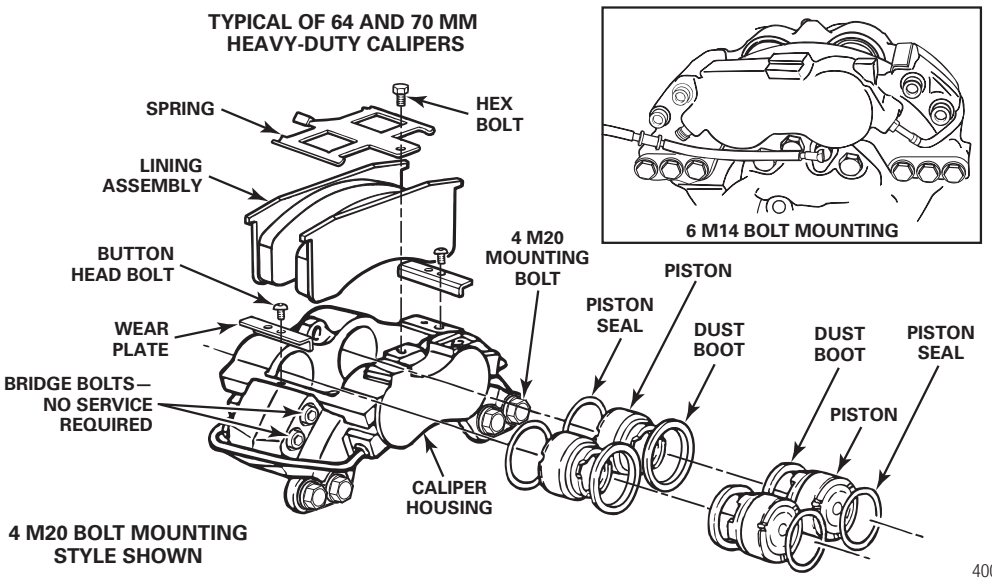
5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal**.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

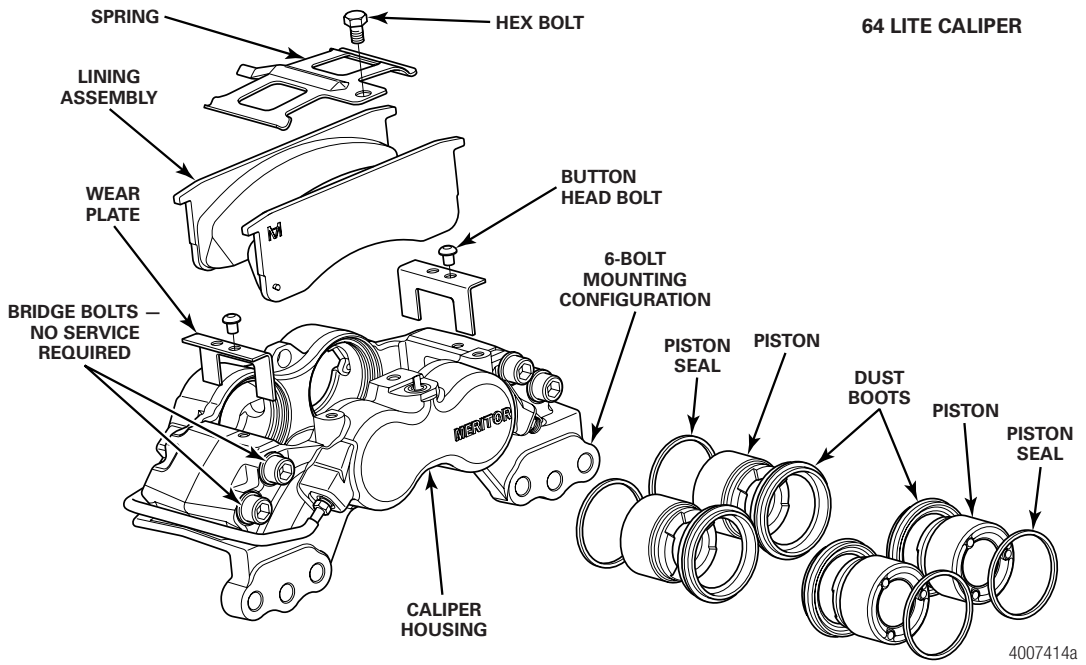
Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

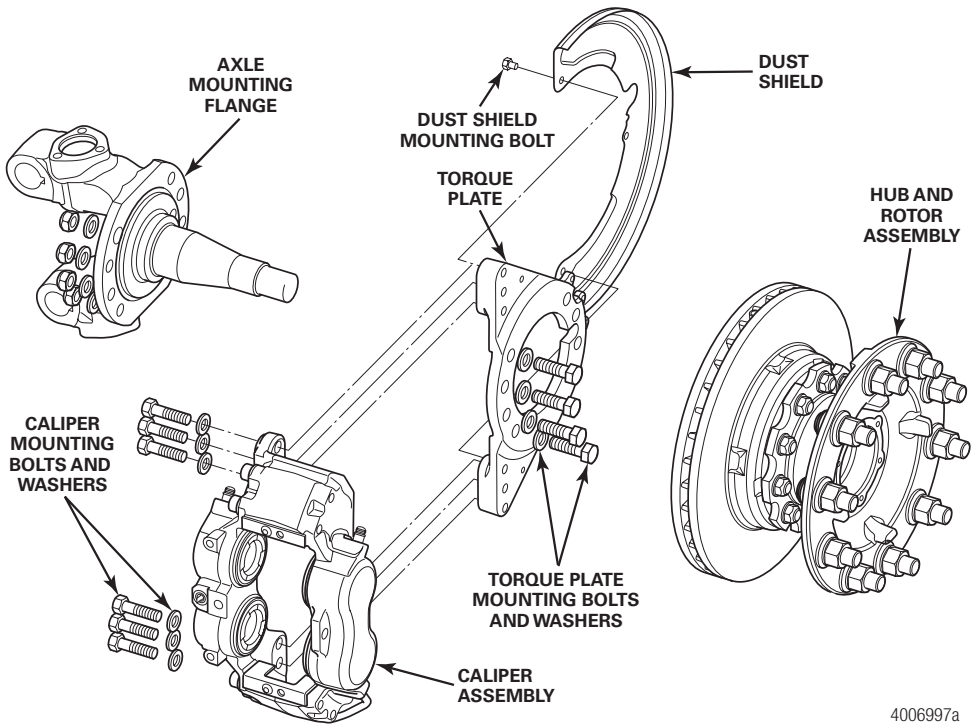
Exploded Views



1 Exploded Views



1 Exploded Views



The general assembly sequence is as follows.

1. Assemble the dust shield to the torque plate. The dust shield option varies by model.
2. Assemble the torque plate to the axle flange.
3. Assemble the hub and rotor assembly.
4. Assemble the caliper over the rotor and bolt it to the torque plate.

2 Introduction

Features

Four-Piston Quadraulic™ Disc Brake Caliper

Meritor Quadraulic™ disc brakes have a four-piston, fixed-mount caliper design for use on both front and rear drive axles. An installation includes the following major components — the caliper assembly, torque plate assembly, optional dust shield, hub or rotor assembly and attaching hardware.

There are three caliper types and they are referenced by the piston diameter: 70 mm, 64 mm and 64 mm Lite. The 64 mm Lite version is not a replacement equivalent for the base 64 mm caliper.

Caliper

Meritor caliper assemblies are designed as follows.

- The caliper assembly consists of two halves assembled with four bolts and washers.
- It includes four hydraulic piston bores, two brake pads, two stainless steel lining wear plates installed with button head bolts, a pad retainer spring and bolt, bleed screw and crossover tube.
- The piston bores contain the pistons, piston seals and piston boots.
- The crossover tubes connect the two halves of the caliper piston to supply brake fluid to the outboard pistons.

How to Identify the Caliper

Check for an assembly number on the side of the caliper for specific handed part numbers.

If a part number is not visible, the calipers can also be identified by piston diameter size. The two sizes available are: 64 mm or 70 mm. They are visually identifiable by boot color (64 mm is red, 70 mm is black).

The 64 mm Lite caliper also has a red boot and is distinguishable from the base 64 mm caliper by the six M16 size mounting bolts.

Torque Plate

The torque plate assembly may have a provision for an anti-lock braking system (ABS) sensor using either a bolt-on bracket, press-in bushing, clearance hole or slot. It also has provisions to mount an optional dust shield to protect the rotor and brake assembly from road contamination. When the ABS system is not used or the sensor is mounted through the axle flange, the supports are not equipped with the sensor bracket.

Hub and Rotor

Meritor hub and rotor assemblies incorporate the following design features.

- The hub and rotor assemblies consist of a hub and rotor, fitted with bearing cups and wheel attachment studs.
- There are two types of rotors used — a U-shaped rotor and a hat-shaped rotor.
- Some rotors are equipped with a cast-in ABS speed sensor tooth wheel, typically with 100 slots. Some rotors have separate ABS speed sensor tooth wheels attached to the rotor with bolts.
- Front hub and rotor assemblies can have various ABS speed sensor tooth wheels such as a separate ring mounted to the inboard end of the hub, ABS teeth integral to the rotor, or a separate ABS ring attached to the rotor by bolts.
- There are various hub configurations offered to accept the 19.5-inch (495.3 mm) eight-hole wheels, as well as 22.5-inch (571.5 mm) 10-hole wheels with the hub-piloted or stud-piloted system.

Operation

The hydraulic caliper assembly consists of a caliper housing and four pistons. The housing is bolted directly to the torque plate. The torque plate is bolted to the axle flange or may be integrated with the axle.

The caliper receives hydraulic fluid pressure by way of the centrally located inlet port. The inlet port can accept either a banjo bolt connection or an inverted flare type connection.

The arrows in Figure 2.1 show the fluid handling from the inlet port to each of the pistons. Also shown is the fluid handling for bleeding air from the caliper. Because there are two bleed screws, a special bleeding sequence is required to remove all air from the system. This procedure is detailed in Section 6.

During a brake application, the hydraulic pressure is uniformly applied to the rear of all pistons. The pistons extend out of the bores and push the brake pads into contact with the rotor. The hydraulic force creates a clamp force resulting in braking. After the brake is released, the pressure is released and the pistons retract.

2 Introduction

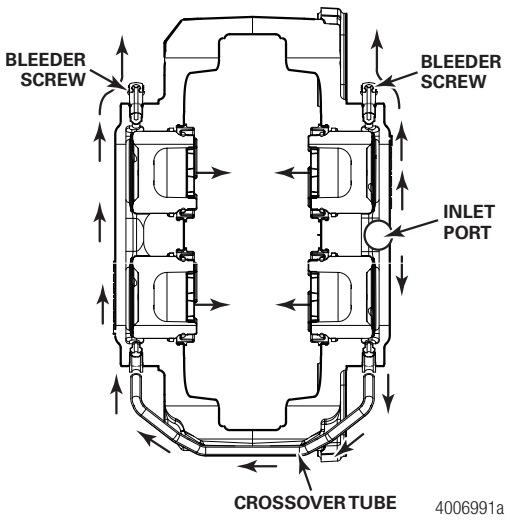


Figure 2.1

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3 Disassembly

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ DANGER

Before you perform any brake service, identify the vehicle's hydraulic system and refer to the service manual for procedures. Some brake application systems are fully-pressurized, and you cannot reduce this pressure by switching off the ignition or removing the battery. To prevent death, serious personal injury or damage to components, you must carefully follow procedures for the hydraulic system you are servicing.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

⚠ ASBESTOS AND NON-ASBESTOS FIBERS WARNING

Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

Removal

Brake Pads

Visually inspect all brake pads. Replace the pads when the remaining lining reaches 1/8-inch (3.175 mm) thickness.

- **If you replace the pads:** Replace all the disc brake pads at the same time to maintain original brake balance.
- **If a complete vehicle pad replacement is not necessary or desirable:** Replace the pads on both wheel ends on the same axle.

Replace the Brake Pads

⚠ CAUTION

The brake pads must be installed when you apply the brakes. If brake pads are not installed, damage to the pistons can result.

1. Wear safe eye protection.
2. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
3. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
4. Remove the wheel and tire assembly according to the manufacturer's recommendation.
5. Remove the master cylinder reservoir filler cap. Check the brake fluid level in the reservoir. If necessary, remove fluid to keep the reservoir from overflowing when compressing the pistons into the caliper.
6. Remove the pad retainer spring bolt. Figure 3.1.

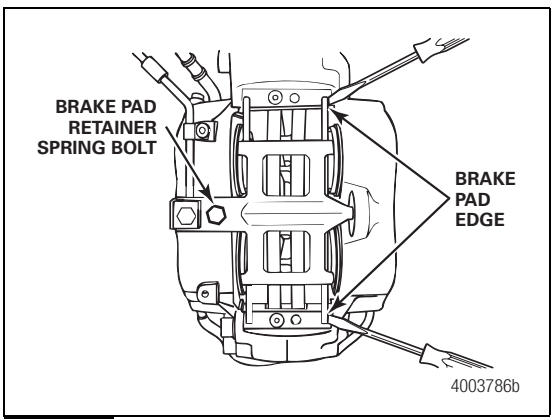

Figure 3.1

7. Insert flat screwdrivers under the brake pad edges. Work the pads out evenly to avoid binding. Figure 3.1.

3 Disassembly

⚠ CAUTION

Avoid placing direct pressure on a piston or damage to components can result.

8. Compress the pistons on each side. Use a piece of plate steel stock over the pistons to uniformly distribute the load. Figure 3.2.

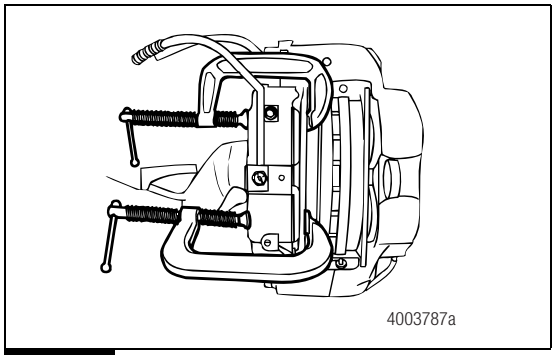

Figure 3.2

9. Inspect the rotor for scoring, warping, cracks, bluing, heat spots or other damage or defects and minimum thickness. Repair or replace if necessary.
10. Inspect the disc brake calipers for leakage, damage or defects to piston boots, seals or pistons. Replace or repair the parts as required.
11. Clean and inspect the lining wear plates. Replace damaged or worn wear plates.

NOTE: The inboard and outboard brake pads are identical, except when they are equipped with a mechanical wear sensor.

12. Install the brake pads. Install pads equipped with a mechanical wear sensor on the inboard side of the caliper. Ensure that the friction surface is against the rotor. Install the pad retainer spring and tighten the bolt. Refer to Section 8. Figure 3.3.

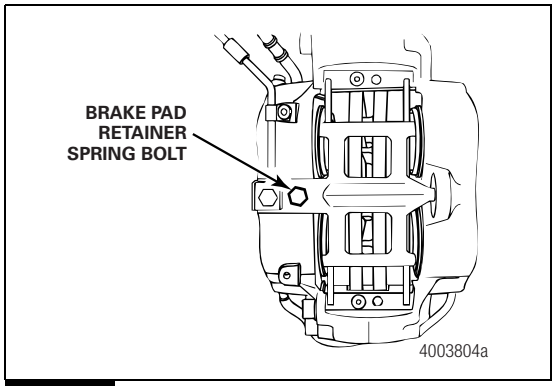

Figure 3.3

13. Fill the master cylinder reservoir with new, clean, high-performance DOT 3 brake fluid or equivalent. Make several brake applications to move the brake pistons and linings out into contact with the brake rotors.
14. Recheck the master cylinder reservoir and top off as necessary to the manufacturer's recommended level.
15. Install the tire and wheel assembly according to the manufacturer's instructions.
16. Lower the vehicle. Road test for correct operation.

Brake Caliper

1. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
2. Remove the tire and wheel assembly according to the manufacturer's instructions.
3. Remove the brake hose hold down clamp bolt, if equipped. Figure 3.4.

3 Disassembly

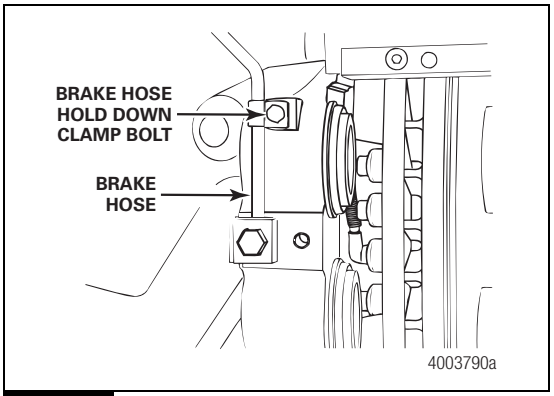

Figure 3.4

4. Remove the brake hose from the caliper. Figure 3.4.

⚠ WARNING

Do not remove the bridge bolts to perform service procedures. If the bridge bolts are removed, you must reinstall them correctly to prevent serious personal injury and damage to components.

5. Remove the caliper-to-torque plate assembly bolts. Do not disassemble the bridge bolts joining the two halves of the caliper. Refer to the bridge bolt procedure in Section 8. Figure 3.5.

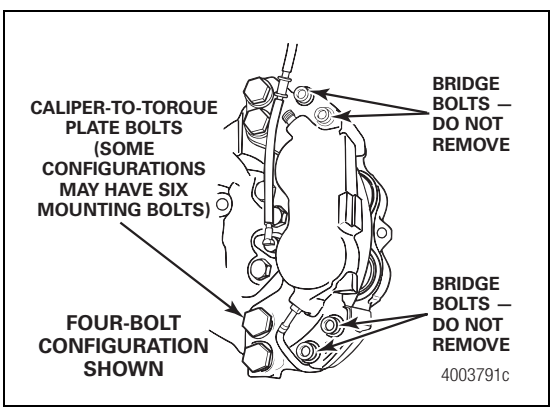

Figure 3.5

Rotor

NOTE: Refer to the vehicle manufacturer's rotor specifications for inspection and service requirements.

1. Check the rotor while assembled to the hub or spoke wheel and mounted on the axle spindle. The lateral runout of the rotor friction surfaces should not exceed 0.015-inch (0.381 mm) total indicator reading (TIR). The thickness variation of the rotor should not exceed 0.0012-inch (0.0300 mm).
   - **If the lateral runout or the thickness variation exceeds the above values:** Resurface or replace the rotor.
   - **If it is necessary to service the rotor, hub, hub seal or bearing:** Remove the caliper according to the procedure in this section.
2. Remove the hub and rotor assembly according to the vehicle manufacturer's recommendation.

Torque Plate

1. Remove the caliper from the vehicle. Refer to the procedure in this section.
2. Remove the dust shield, if installed, from the torque plate.
3. Remove the hub and rotor assembly according to the vehicle manufacturer's recommended service procedure.
4. Remove the ABS sensor, if equipped.
5. Remove the torque plate-to-axle mounting bolts. Figure 3.6.

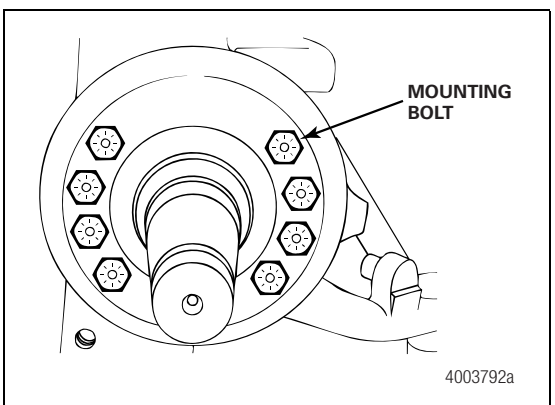

Figure 3.6

Disassembly

Brake Caliper

1. Remove the brake caliper and brake pads. Refer to the procedures in this section.
2. Drain all fluid from the caliper.
3. Push all four pistons to the bottom of their bores.
4. Remove the piston boots by prying the metal ring portion of the boot out of the bore with a screwdriver. Use care to avoid damage to the piston or bore. Discard the boots. Figure 3.7.

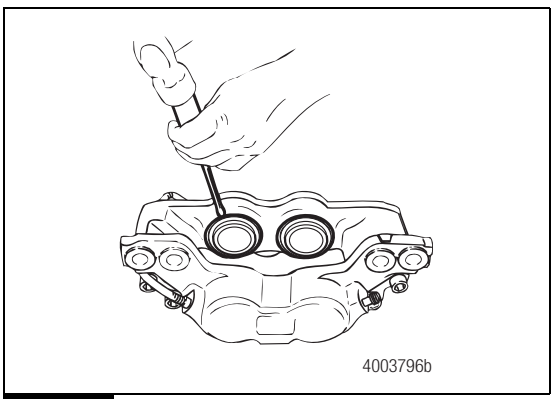

Figure 3.7

5. Remove the crossover tube.

⚠ WARNING

When you use compressed air to remove the pistons from the caliper bore, do not place your hands or fingers near the bore to catch or protect the pistons. Serious personal injury can result.

6. Install a plug screw in the inlet port on the inboard caliper half.
7. Place a section of plate stock across the pistons to be removed. Use a C-clamp to hold the plate against the pistons on one side of the caliper where the pistons are to be removed. Figure 3.8.

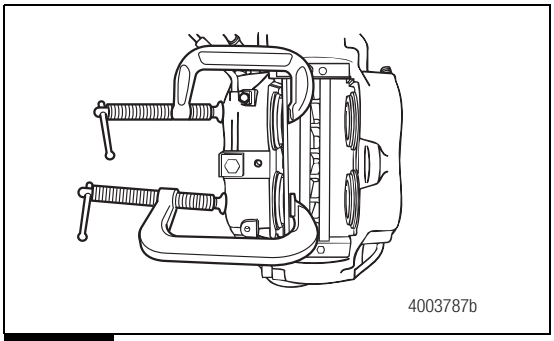

Figure 3.8

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⚠ CAUTION

When you remove the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.

8. Apply low air pressure, no more than 25 psi (172 kPa), with a rubber nosed air fitting to the crossover tube port. Figure 3.9.

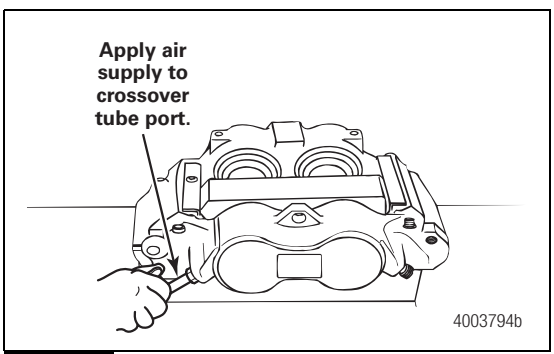

Figure 3.9

⚠ WARNING

Ensure the pistons are installed in the housing before you pressurize it to prevent serious personal injury and damage to components.

9. Gradually open the C-clamp to allow the pistons to move out evenly until free.
10. Repeat the procedure for the other caliper half.

3 Disassembly

⚠ CAUTION

Install a new caliper if the caliper bores are excessively scored or corroded. Do not hone the caliper bores, which can affect piston fit and operation. Damage to components can result.

11. Remove the piston seals with a non-metallic device. Discard the seals. Do not nick, scratch or scar the piston bores or seal grooves. Do not hone the caliper bores.
    - **If the caliper bores are excessively scored or corroded:** Install a new caliper.

⚠ CAUTION

The outside diameter of the piston is the caliper's primary sealing surface and is manufactured to very close tolerances. Replace a piston if the outside diameter is damaged. Do not refinish or use abrasives, including an emery cloth, on the piston. Damage to components can result.

12. Inspect the outside diameter of the pistons for scoring, nicks, corrosion, wear and damage.
    - **If any of these conditions exist:** Replace the pistons. Do not refinish or use abrasives.
13. Inspect the caliper bore for scoring, nicks, corrosion, wear and damage.
    - **If any of these conditions exist:** Replace the caliper.

⚠ CAUTION

Use a crocus cloth to remove minor stains and corrosion from the caliper bore. Do not use abrasives, including an emery cloth. If you cannot remove minor stains and corrosion, replace the caliper bore to avoid damage to components.

14. Inspect the caliper bore for minor stains and corrosion.
    - **If any of these conditions exist:** Use a crocus cloth to remove stains or corrosion. Clean the caliper bore after using a crocus cloth. Do not use abrasives, including an emery cloth.
    - **If you cannot remove stains and corrosion from the caliper bore:** Replace the caliper.

4 Prepare Parts for Caliper Assembly

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

Clean, Dry and Inspect Parts

Clean Parts

For Ground or Polished Metal Parts

⚠ CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts can result.

Use a cleaning solvent or kerosene or diesel fuel to clean ground or polished metal parts or surfaces.

For Rough Metal Parts

Use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean rough metal parts. If you use a hot solution tank, follow the instructions below.

1. Leave the rough parts in the tank until they are completely cleaned and heated.
2. Remove the rough parts from the tank.
3. Wash the parts with water until you remove the alkaline solution.

Dry and Inspect Parts

1. Use soft, clean paper or cloth rags or compressed air to completely dry parts immediately after you clean them.
2. Carefully inspect all parts for wear or damage before you assemble them.
3. Repair or replace worn or damaged parts.

Apply Corrosion Protection

1. Apply a thin layer of brake fluid to cleaned, dried parts. Be careful that you do not apply the fluid to the linings or rotor.
2. If you will store the parts, apply a rust inhibitor, that prevents corrosion and rust, to all surfaces. Store parts inside to prevent rust and corrosion.

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5 Assembly and Installation

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Assembly

Brake Caliper

When using compressed air, use air lines that are completely free of oil and moisture. All brake parts must be clean and completely dried of cleaning fluid. Use only Meritor replacement parts to ensure correct caliper performance.

1. Assemble the crossover tube. Tighten the crossover tube nuts. Refer to Section 8. ⓣ
2. Ensure the parts are clean and free of debris. Use compressed air to clean out and dry the grooves and passages.
3. Dip new piston seals in new, clean DOT 3 hydraulic brake fluid and install into the piston seal groove in the caliper piston bores. Verify that they are correctly seated.
4. Apply a thin film of silicone grease or brake fluid to the caliper bore seal land between the piston boot and seal groove. Apply the grease or brake fluid around the entire circumference of the caliper bore. Figure 5.1.

Figure 5.1

5. Apply DOT 3 hydraulic brake fluid to the outside of the caliper pistons and install them in the caliper bores with the piston steel cap facing out, verifying that they are square to the bore. Figure 5.2.

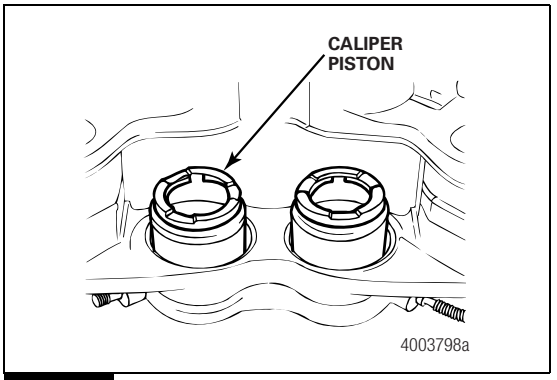

Figure 5.2

6. Press the pistons into the bores one at a time. Use a block and C-clamp to press the piston into the housing until lightly seated. Repeat this procedure for the other pistons. Figure 5.3.

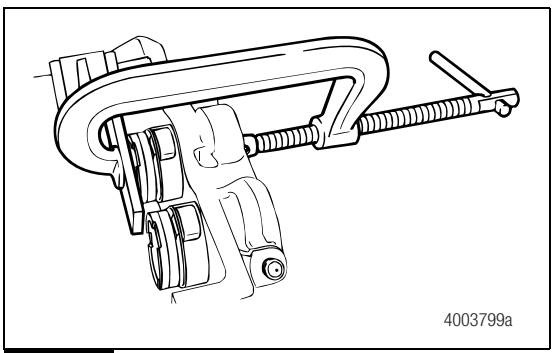

Figure 5.3

7. Install the piston boots over the projecting ends of the pistons and press the ring side of the boots into the boot bore with a seal driver or other method to evenly install the boot. An old bearing cup equal to the boot ring size helps install the boots. Verify that the piston boot bead is seated back against the shoulder of the projecting end of the piston. Boots for the 64 mm and 70 mm pistons are color-coded. The 64 mm boot is red and the 70 mm is black. Figure 5.4.

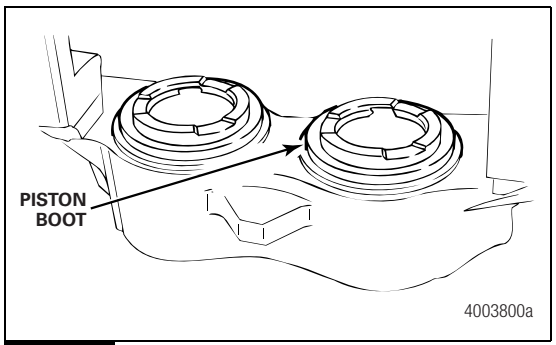

Figure 5.4

8. If required, replace the two stainless steel wear rails by removing the button head bolts.

Installation

Torque Plate

1. Install the torque plate mounting bolts. Tighten the bolts to the specified torque. Refer to Section 8. Figure 5.5.

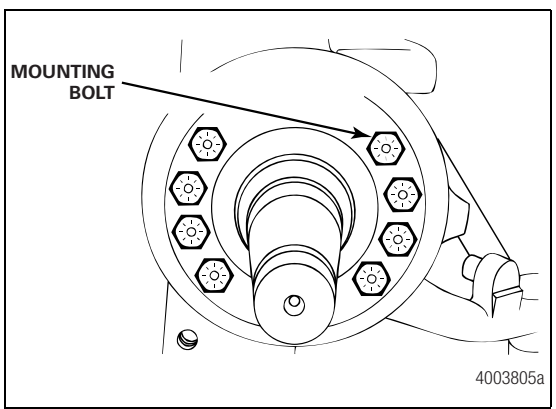

Figure 5.5

2. If equipped, install the ABS sensor according to the vehicle manufacturer's recommended service procedure.
3. Install the hub and rotor assembly according to the vehicle manufacturer's recommended service procedure.
4. Install the dust shield, if equipped.
5. Install the caliper. Refer to the procedure in this section.

Rotor

1. Install the hub and rotor assembly according to the manufacturer's recommended service procedures. Verify that the mating surfaces of the hub or spoke wheel and rotor are clean and free of rust build-up.
2. Check the rotor while assembled to the hub or spoke wheel and mounted on the axle spindle. The lateral runout of the rotor friction surfaces should not exceed 0.015-inch (0.381 mm) total indicator reading (TIR). The thickness variation of the rotor should not exceed 0.0012-inch (0.0300 mm).
   - **If the lateral runout or the thickness variation exceeds the above values:** Resurface or replace the rotor.

Caliper

1. Inspect the caliper before you reinstall it onto the torque plate. The pistons should be fully retracted into the caliper. Check to ensure the piston boots are not loose or damaged. Verify the piston boots are fully seated into the housing. If any leakage, damage or defect is found, it may be necessary to disassemble or replace the caliper. Figure 5.6.

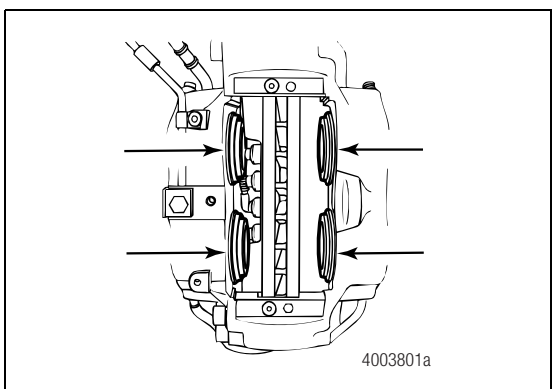

Figure 5.6

2. Install the caliper over the rotor. Install the washers and start the caliper-to-torque plate mounting bolts by hand.
3. Depending on the caliper configuration, tighten the four M20 mounting bolts or the six M14 mounting bolts. Refer to Section 8. ⓣ
4. Install the brake hose. Figure 5.7.

5 Assembly and Installation

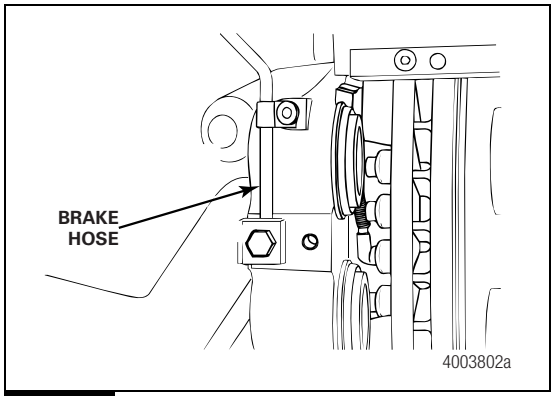

Figure 5.7

5. Secure the brake hose hold-down clamp with the bolt. Figure 5.8.

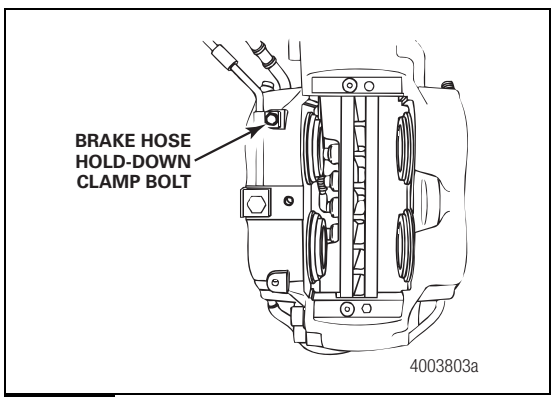

Figure 5.8

Brake Pads

1. Inspect the rotor for scoring, warping, cracks, bluing, heat spots or other damage or defects and minimum thickness. Repair or replace if necessary.
2. Inspect the disc brake calipers for leakage, damage or defects to piston boots, seals or pistons. Replace or repair the parts as required.
3. Clean and inspect the lining wear plates. Replace damaged or worn wear plates.

NOTE: The inboard and outboard brake pads are identical, except when they are equipped with a mechanical wear sensor.

4. Install the brake pads. Install pads equipped with a mechanical wear sensor on the inboard side of the caliper. Ensure that the friction surface is against the rotor. Install the pad retainer spring and tighten the bolt. Refer to Section 8. Figure 5.9.

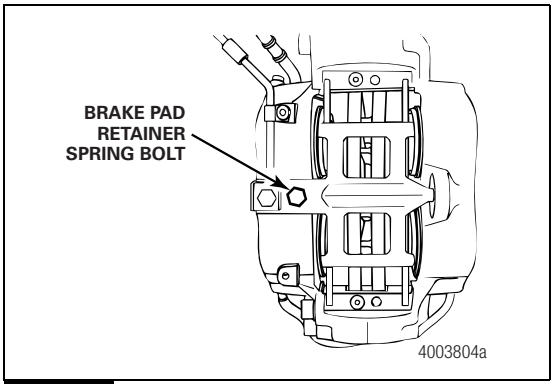

Figure 5.9

5. Fill the master cylinder reservoir with new, clean, high-performance DOT 3 brake fluid or equivalent. Make several brake applications to move the brake pistons and linings out into contact with the brake rotors.
6. Recheck the master cylinder reservoir and top off as necessary to the manufacturer's recommended level.

⚠ CAUTION

To remove air from the caliper, you must use the two bleed screws in a specific sequence to correctly bleed the brakes. Otherwise air can enter the system and affect brake performance. Damage to components can result.

7. Bleed the brake system according to the vehicle manufacturer's procedure. Bleed the caliper according to the procedure specified in Section 6 of this manual.
8. Install the tire and wheel assembly according to the manufacturer's instructions.
9. Lower the vehicle. Road test for correct operation.

6 Inspection

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Inspect Parts

Caliper

1. Clean the area around the brake hose. Use brake parts cleaner.
2. Inspect the piston and boots for wear and damage. Replace worn or damaged parts.
3. Inspect the caliper lining wear plates for wear and damage. Replace worn or damaged wear plates.
4. Inspect the housing for cracks or damage. Replace a cracked or damaged housing.

Torque Plate

1. Inspect the caliper mounting area of the torque plate for rust or corrosion. Replace a damaged or worn torque plate.
2. Use a wire brush to clean the caliper mounting area.
3. Inspect the torque plate for cracks or elongated bolt holes.
   - **If these conditions exist:** Replace the torque plate.

Brake Caliper Bleeding Procedure

⚠ DANGER

This bleed sequence refers to bleeding the caliper and does not consider the hydraulic application system requirements. Identify your vehicle hydraulic application system type and refer to that service manual before you perform any brake service. You must adhere to the hydraulic application system bleeding procedures to prevent death, serious personal injury or damage to components.

Refer to the manufacturer's service information for ABS bleeding instructions.

1. Check the master cylinder reservoir and fill, if necessary, with DOT 3 or DOT 4 brake fluid.
2. Bleed the brakes in the following order: right rear, left rear, right front and left front.

⚠ CAUTION

When you bleed a four-piston caliper, monitor the brake fluid level to ensure you do not drain the system. Add brake fluid to the reservoir as needed to prevent damage to components during operation.

Always install new brake fluid into the caliper. Discard old brake fluid. Do not reuse it. Damage to components can result.

NOTE: Each four-piston caliper is equipped with two bleed screws. To ensure air is removed from a caliper, the bleed sequence is inboard, outboard, and repeat inboard.

3. Install a section of clear, flexible tubing with a 1/4-inch inner diameter over the inboard bleeder. Insert the other end of the tubing into a container to collect the purged brake fluid. Discard the brake fluid. Do not reuse old brake fluid.
4. If a pressurized bleeding system is not required by the vehicle manufacturer's service procedures, apply and hold the brakes to pressurize the system.
5. Repeat the procedure for the outboard bleed screw.
6. Repeat the procedure for the inboard bleed screw.
7. Tighten the bleed screws to specification. Refer to Section 8.
8. Test the brakes prior to returning the vehicle to service.

7 Troubleshooting

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Brakes

Conditions	Possible Causes	Correction
Excessive Pedal Effort	Pads worn below minimum thickness	Install new pads.
	Faded, overheated condition, glazed pads, blued or heat-checked rotors	Replace the rotor and reface pads if sufficient lining remains.
	Grease, oil or brake fluid on linings	Install new pads in the axle sets.
	Seized or frozen pistons	Disassemble the calipers and free pistons, or replace the caliper.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.
Pedal Pulsation (Brake Roughness or Chatter)	Excessive lateral runout of brake rotor	Check with a dial indicator. Install a new rotor if the runout exceeds the maximum specified.
	Excessive out-of-parallelism of brake rotor	Check the parallelism or rotor thickness variation with a micrometer. Resurface the rotor or install a new rotor if the parallelism exceeds the maximum allowed.
	Loose or worn steering or suspension parts	Replace the parts and realign.
	Excessive front bearing clearance	Readjust the bearing to specifications.
Vehicle Pulls to One Side	Brake fluid, oil or grease on linings	Install new pads in the axle sets.
	Unmatched linings, uneven lining wear, distorted pads	Install new pads in the axle sets.
	Rough rotor surfaces on one rotor	Resurface or replace the rotor in the axle sets.
	Seized or frozen pistons	Disassemble the caliper and repair or replace.
	Loose caliper mounting bolts	Tighten to specifications.
	Uneven tire pressure, tread wear or size, right to left	Equalize to the recommended pressures. Install the correct size tires with good tread.
	Excessive rotor parallelism or runout	Resurface or replace the rotor.
	Restricted hose or line	Examine the hoses and lines, and replace as necessary.
	Front end out of alignment	Reset the alignment.

7 Troubleshooting

Conditions	Possible Causes	Correction
Leaky Caliper	Wheel seal damaged. A damaged wheel seal can make the wheel end and caliper appear as the problem.	Pressurize the caliper to determine the source of the leak. If necessary, replace the wheel seal.
	Crossover tube damaged	Repair or replace the components or housing as necessary.
	Bleeder screw damaged	Repair or replace the components or housing as necessary.
	Inlet port damaged	Repair or replace the components or housing as necessary.
	Cylinder bore surface scored or corroded	Disassemble the calipers, clean the bore and replace the seals and boots.
	Caliper piston seal damaged or worn	Disassemble the calipers and install new seals and boots.
	Caliper piston damaged	Replace the piston.
No Braking Effect or Excessive Pedal Travel	Reservoir fluid level low	Check for causes of fluid leak, repair as required and refill the reservoir. Bleed the system as needed.
	Air in the caliper	Bleed the caliper as needed. Refer to the brake caliper bleed procedure.
	Air in the hydraulic application system	Refer to the hydraulic application system manual for the correct bleeding procedure.
	Malfunction of the hydraulic application system	Refer to the hydraulic application system manual for the diagnostic procedures.
	Caliper piston seal damaged	Disassemble the caliper and replace the piston seals. Replace the piston if it is damaged.
	Excessive rotor runout or bent rotor	Check the rotor with a dial indicator. Install a new rotor if the runout exceeds the maximum specified.
	Worn or excessively loose wheel bearings	Adjust or replace the bearings as needed.
	Low quality brake fluid	Drain and clean the system. Replace with the recommended brake fluid.
	Weak brake hose that expands under pressure	Replace the hoses.
Brake Noise (Chatter)	Excessive lateral runout of rotor	Check the runout with a dial indicator. Install a new rotor if the runout exceeds the maximum specified.
	Lack of rotor parallelism	Check the parallelism with a micrometer. Resurface or install a new rotor as required.
	Loose wheel bearing	Readjust the bearing to the specified torque.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.

7 Troubleshooting

Conditions	Possible Causes	Correction
Brake Noise (Scraping)	Rust or mud build-up on edges of rotor and on caliper housing	Clean or replace as necessary.
	Worn pad or pad installed backward	Replace the pads in the axle sets only with the friction surface against the rotor.
	Incorrect caliper alignment permitting rotor to scrape on housing	Correct the alignment.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.
Brake Noise (Groan)	Pressure on the brake pedal too light	Slightly increase the pedal effort to eliminate the noise.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.
Brake Noise (Rattle)	Excessive clearance between the shoe and caliper	Install new pads.
	Pad retainer plate missing or not correctly positioned	Install a new pad retainer spring or position it correctly.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.
Brake Noise (Squeal)	Glazed pads	Resurface or replace the pads in the axle sets only.
	Weak pad retainer spring	Install a new pad retainer spring.
	Foreign material embedded in linings	Replace the pads in the axle sets only.
	Incorrect pad friction material	Install the manufacturer recommended material.
	Incorrectly installed brake pads, backing plate facing the rotor	Inspect for damage and install the pads with the friction material toward the rotor.

8 Specifications

Torque Specifications

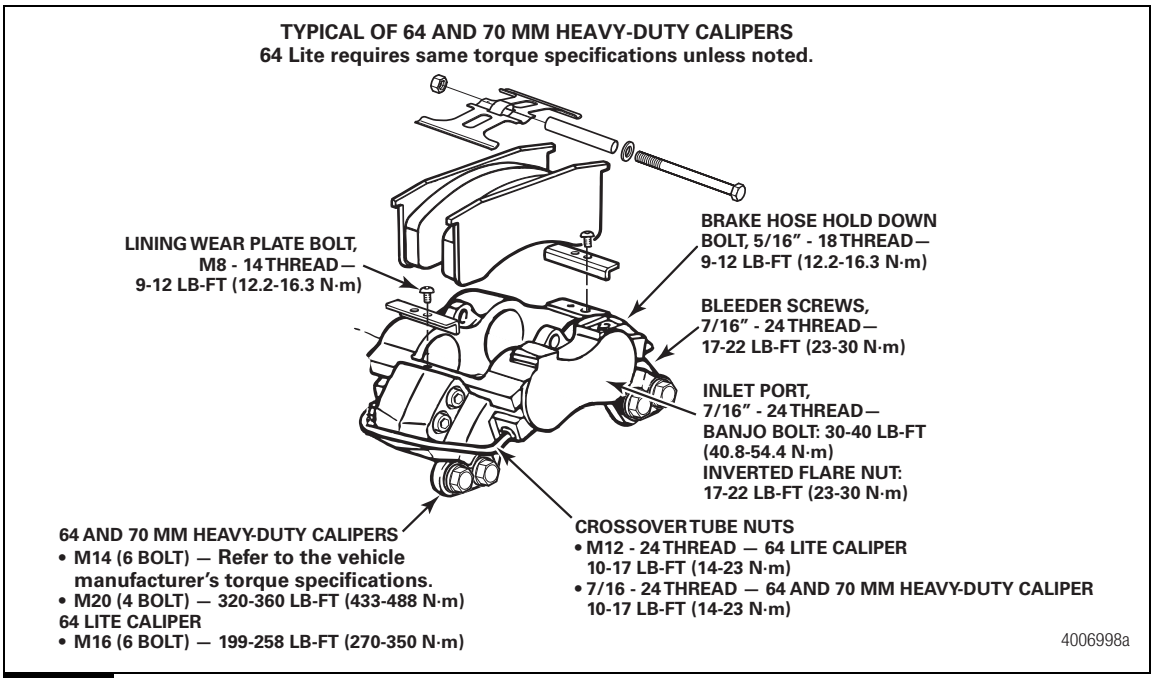

Figure 8.1

8 Specifications

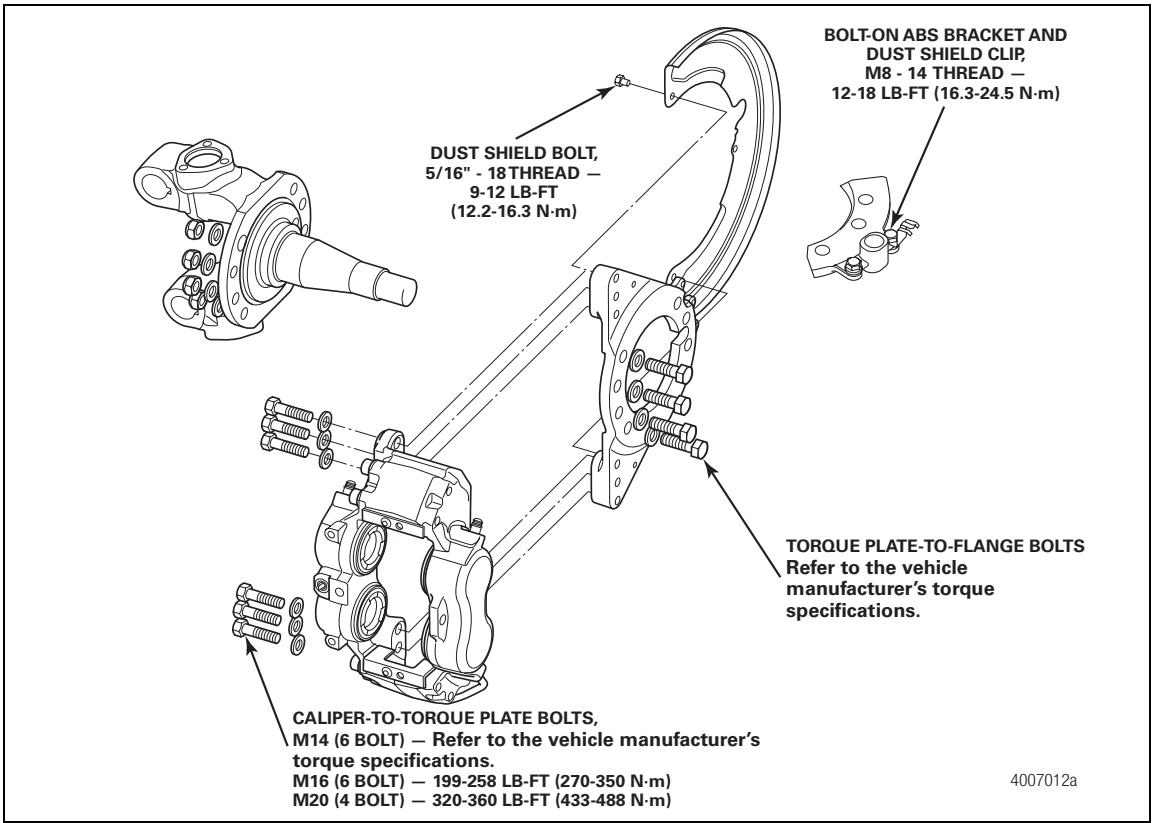

Figure 8.2

Bridge Bolts

⚠ WARNING

Do not remove the bridge bolts to perform service procedures. If the bridge bolts are removed, they must be reinstalled correctly or serious personal injury, brake loss or damage to components can result.

If the bridge bolts were removed, install new bridge bolts and tighten them in the correct sequence according to the following procedure. To obtain bolt hardware kits, call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355. Do not rebuild the calipers with used caliper parts.

1. Verify the two caliper halves are seated. If necessary, lightly press the halves together until correctly seated.
2. Loosely assembly all bridge bolts.
3. Perform the following two step bolt tightening procedure.
   A. Tighten the bolts to an initial torque of 50 lb-ft (68 N•m) in the sequence 1, 2, 3, 4. Figure 8.3.
   B. Use torque angle equipment to turn the bolts 70 +3/–2 degrees in the sequence 1, 2, 3, 4.

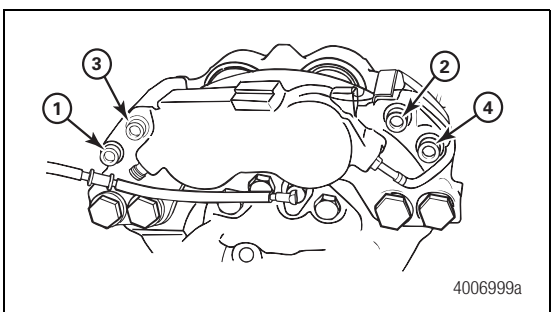

Figure 8.3

8 Specifications

Four-Piston Quadraulic™ Disc Brake Components

Description	Specification
Brake Pad — Thickness Above Metal (New) Minimum Thickness Above Metal (Discard)	0.73" (18.5 mm) 0.125" (3.2 mm)
Brake Fluid — High-Performance Brake Fluid (Per Manufacturer's Recommendation)	DOT 3 or DOT 4

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Printed in USA
Revised 08-09
Maintenance Manual MM-2075 (16579)

ArvinMeritor™

Overview

Coolant is circulated through the closed presurized system by the engine's water pump whenever the engine is running. When the engine is cold, coolant flow through the radiator is blocked by a conventional thermostat mounted at the engine coolant outlet. The closed thermostat causes the coolant to be directed through a bypass integral to the engine block when the engine is cold.

As the engine warms, heat is transferred to the coolant and the thermostat gradually opens the radiator circuit while increasingly obstructing the bypass. Coolant from the engine"s coolant outlet increasingly enters the radiator at the top, passes through the radiator's coils and leaves the radiator at the bottom on its way back to the engine coolant inlet. When the engine has reached full normal operating temperatature, the thermostat is fully open, the bypass path is closed, and all coolant circulates through the radiator.

During normal running, engine cooling is regulated by controling the effectiveness of the radiator. This is accomplished by powering and de-powering the fan which draws ambient air over the coils of the radiator. On Forward Engine All Americans, the fan is mounted to an electromagnetic fan clutch assembly mounted to the front of the engine and driven by the fan belt. The engagement and disengagement of the fan clutch is controlled by the engine ECM. The electrically-controlled fan clutch of the All American Forward Engine is described in the electrical chapter.

On Rear Engine All Americans, the fan is driven by a remotely mounted hydraulic motor. Unlike the single-speed on/off cycling of the fan on Forward Engine All-American's, the speed of the fan on Rear Engine units is variable, and runs faster or slower as controlled by temperature sensors. The hydraulic fan motor of the All American Rear Engine is described in the Hydraulic System chapter.

On buses operated in colder climates, the radiator may be fitted with optional Radiator Shutters, a vane-like assembly which serves to block air from passing over the radiator coils. This prevents over-cooling and aids warm-up of the coolant so that interior heaters become effective sooner. The Radiator Shutters may be either hydraulically controlled (powered by engine oil pressure), or pneumatically controlled (powered by air pressure from the supply tank of units with air brakes or air suspension).

The cooling system components are plumbed using either standard black rubber hoses or optional hoses which are blue in color and typically have longer life.

The bus may be fitted with an optional Perry Coolant Filter, which is attached to the engine water jacket at two loctions, creating an alternate "side path" for coolant to flow. The filter traps contaminates as coolant circulates through the replaceable filter.

Engine coolant also circulates through a separate transmission cooler. Unike the coolant filter, this poriton of the coolant's flowpath is not a parallel "alternate path" of the cooant flow. Once the engine has reached normal operating temperature and the thermostat has fully opened, all the coolant passes through the transmission cooler, "in series" with the radiator. The inlet side of the transmission cooler receives coolant that has already passed through the radiator. Inside the transmission cooler, the water circulates around a coil through which transmission fluid circulates. At

normal operating temperatures, the engine coolant is signifciantly cooler than the the transmission fluid and thereby serves to cool the transmission fluid. In extremely cold climates, during engine warm-up, the warming engine coolant helps bring the transmission fluid up to sufficient temperature for the transmission to operate.

Heated engine coolant also provides the heat for the bus's interior heating units. The heater plumbing circuit is a "parallel" circuit which begins at the high pressure side of the engine water jacket, cycles through the various heater elements and returns by way of an inlet to the transmission cooler. There it rejoins the coolant bath circulating through the transmission cooler, and thereby finds its way back to the engine inlet. A cut-off valve is provided at engine heater outlet pipe and at the transmission cooler's heater circuit inlet. This allows the heating circuit to be blocked at both ends when servicing the cooling system or when it is desireable to prevent heaters from warming up during summer months.

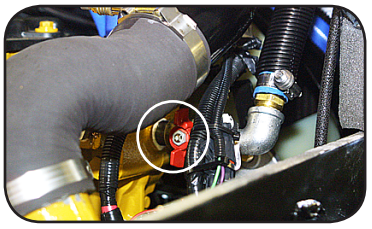
The heater supply tubing from the engine leads to the Driver's remote heater valve, an electrically-controlled valve which enables the Driver to control the effectiveness of all heaters by regulating the amount of engine coolant circulating through the heater circuit.

Depending upon the heaters configuration, the heater circuit may be equipped with an optional auxilliary water pump to help force-circulate coolant through the heaters. The auxilliary pump on Forward Engine All Americans resides in a dedicated housing mounted to the floor along the heater piping. On Rear Engine All Americans, the auxilliary water pump is mounted forward of the radiator and is accessible from under the rear overhang. The inlet side of the auxilliary pump receives coolant from the high pressure side of the engine water jacket. The outlet side leads to the series of heaters and then returns via the transmission cooler as described above. Thus, the transmission cooler receives coolant that has cooled by transferring its heat to the heaters and/or by passage through the radiator.

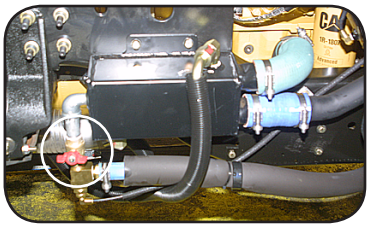
The cooling filler neck is connected to a deaeration tank located at the highest point of the cooling system flow circuits. Tubes lead to the deaeration tank from the tops of the radiator, the engine, and the transmission cooler. This provides a path for air bubbles in the circuits to rise to the deaeration tank. When pressure inside the system rises sufficiently to overcome the spring of the filler neck's pressure cap, air that has collected in the top of the deaeration tank escapes, reducing the system pressure to normal. A sight glass is provided on the deaeration tank to inspect coolant level. Coolant level should be maintained at just above the sight glass (the glass is full).

On Forward Engine All American's the radiator must be removed to gain access to certain service components on the front of the engine. To facilitate this, an option popularly installed on Forward Engine buses is a swing out radiator, which provides limited access without requiring draining of the coolant.

The three main symptoms of trouble in the cooling system are overheating, overcooling, and loss of coolant. A cooling system should first be diagnosed by a thorough visual inspection. Debris accumulation in the radiator fins or bent fins restricting airflow can cause overheating. If visual inspection reveals no cause, tools and test equipment will be needed to proceed.



Forward Engine heater supply cutoff valve. Accessible from interior engine compartment hood.

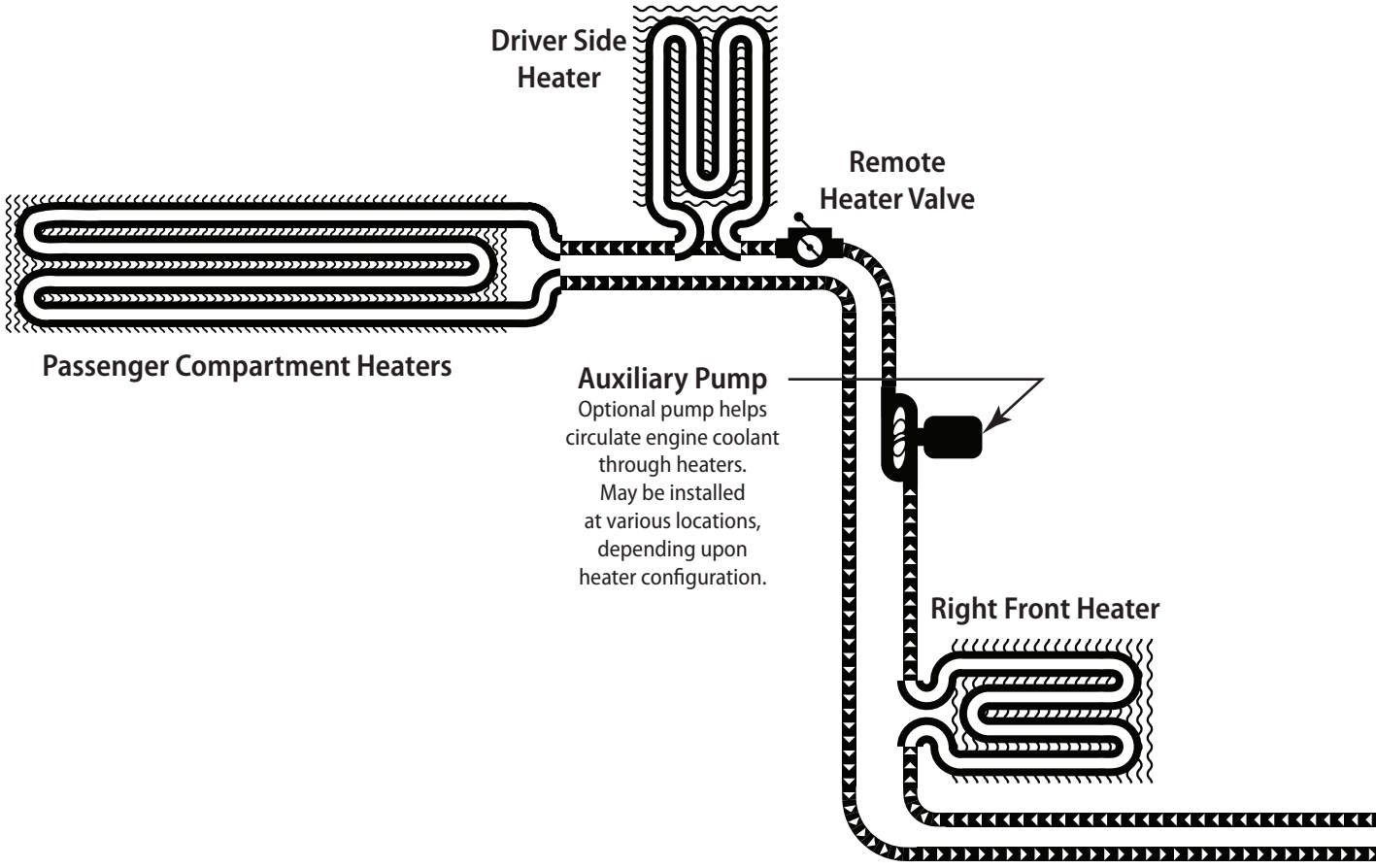


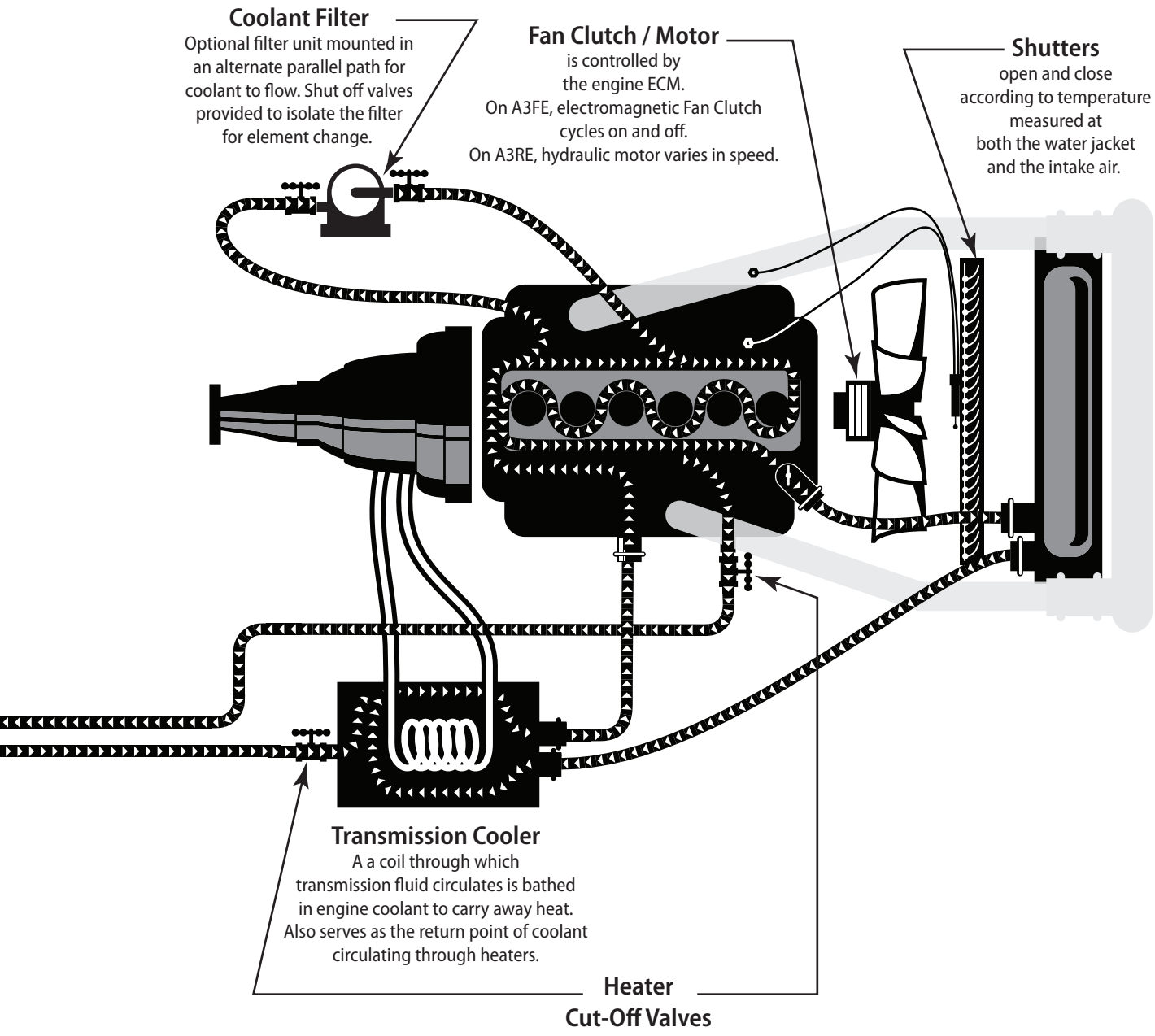
Forward Engine heater return cutoff valve. Accessible from under the bus, forward of the entrance stepwell.

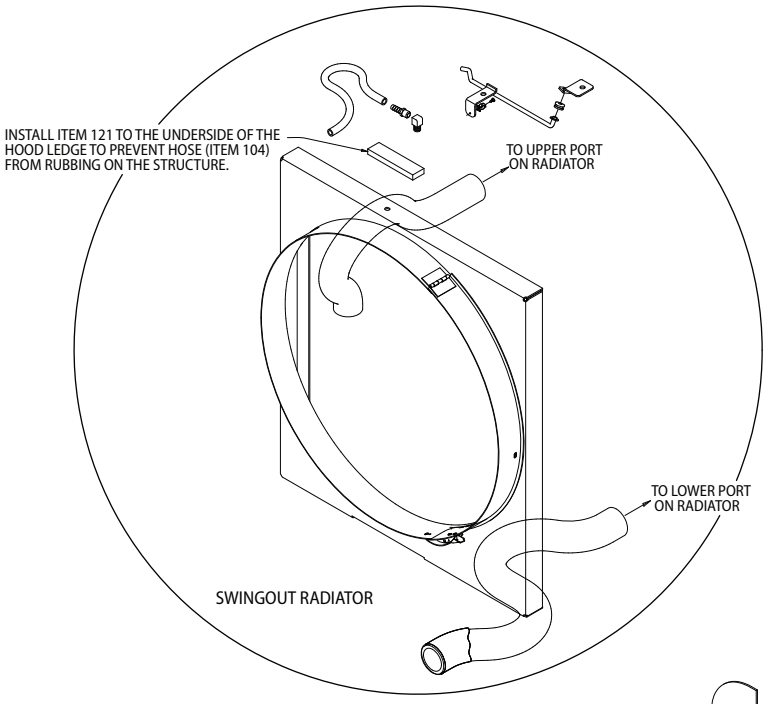
When excessively high operating temperature is observed, first check for proper fluid level at the sight glass of the deaeration tank. If the fluid level is low and cannot be maintained without constant refill, inspect for leaks at pipe and hose connections. Also look for damaged hoses due to heat or chaffing from incorrect routing. Remember that the heater system is a potential area for leaks. The heating system can be isolated by closing the gate valves at the engine's heater outlet and the transmission cooler's inlet.

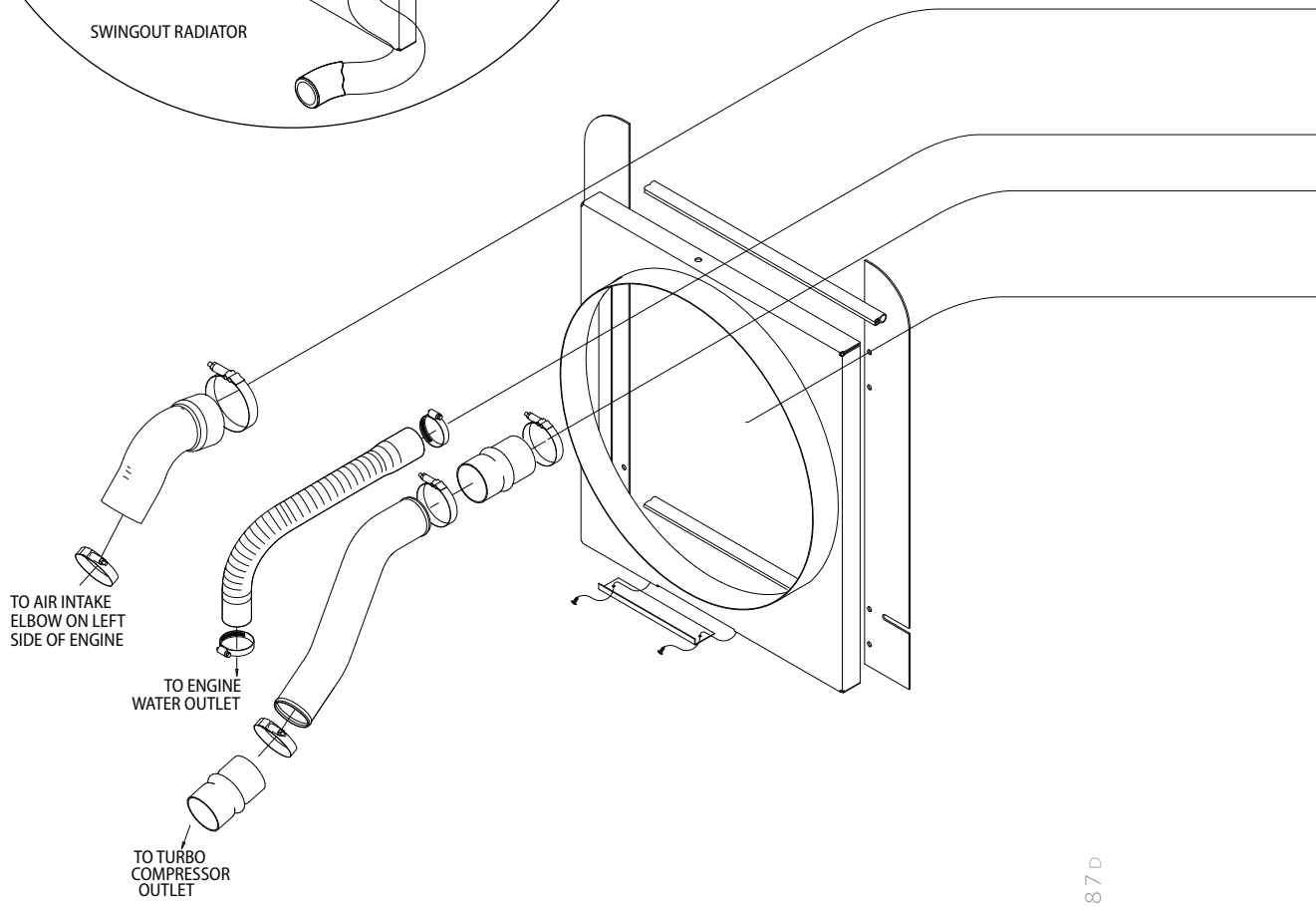
In the case of overheating, the next step is to verify the proper operation of the thermostats. Refer to the appropriate engine manufacturer's service publication for instructions on the removal and testing of the thermostats.

WARNING ***The engine, coolant, and transmission fluid may be very hot (possibly above the boiling point at atmospheric pressure). Allow the system to cool completely before working on it. Engine coolant use and disposal is governed by environmental regulations. Read carefully and abide by the warnings and guidelines on the coolant label.***


Driver Side Heater
Remote Heater Valve
Passenger Compartment Heaters
Auxiliary Pump
Optional pump helps circulate engine coolant through heaters. May be installed at various locations, depending upon heater configuration.
Right Front Heater


Coolant Filter
Optional filter unit mounted in an alternate parallel path for coolant to flow. Shut off valves provided to isolate the filter for element change.
Fan Clutch / Motor
is controlled by the engine ECM.
On A3FE, electromagnetic Fan Clutch cycles on and off.
On A3RE, hydraulic motor varies in speed.
Shutters
open and close according to temperature measured at both the water jacket and the intake air.
Transmission Cooler
A a coil through which transmission fluid circulates is bathed in engine coolant to carry away heat. Also serves as the return point of coolant circulating through heaters.
Heater
Cut-Off Valves





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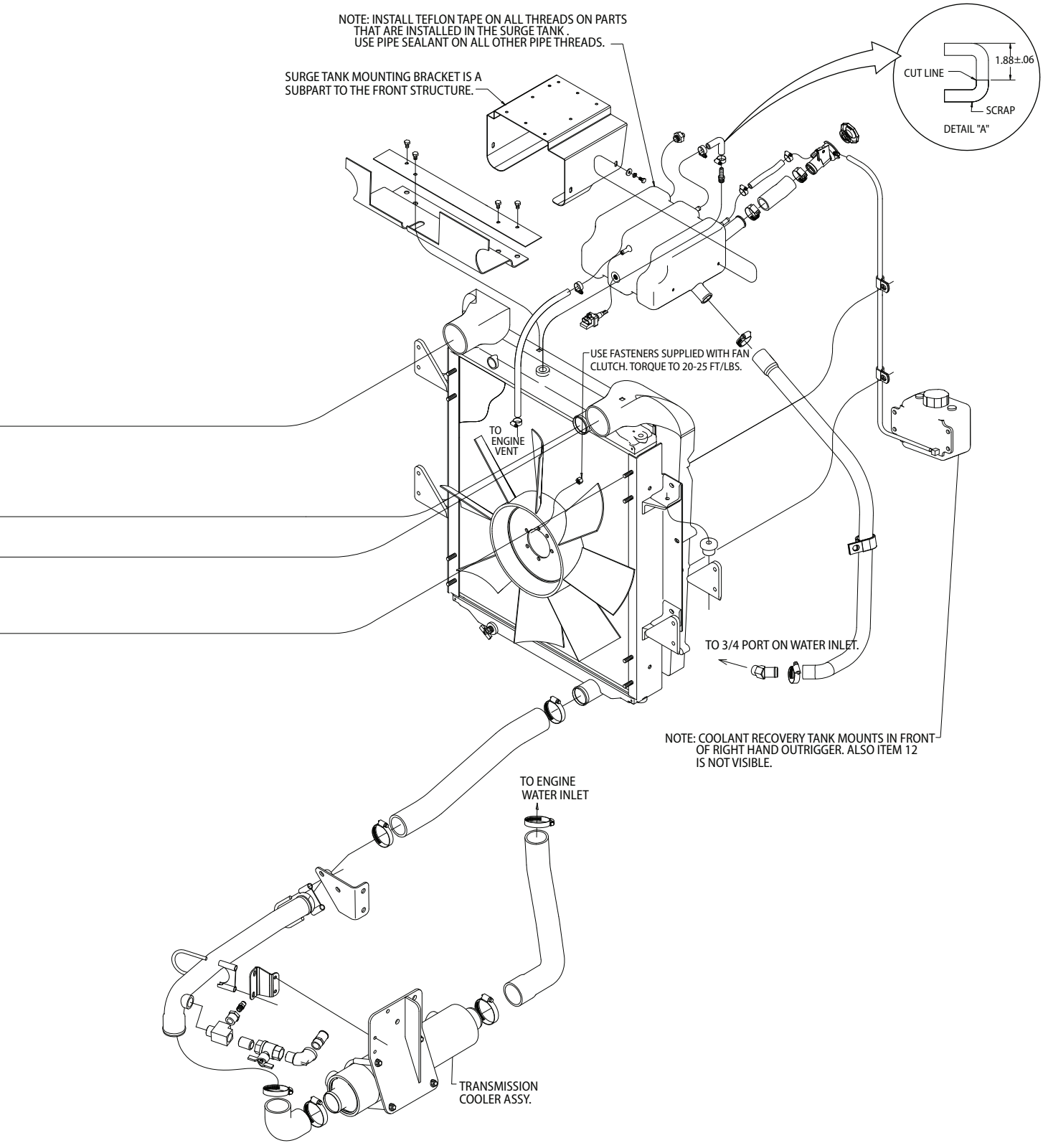
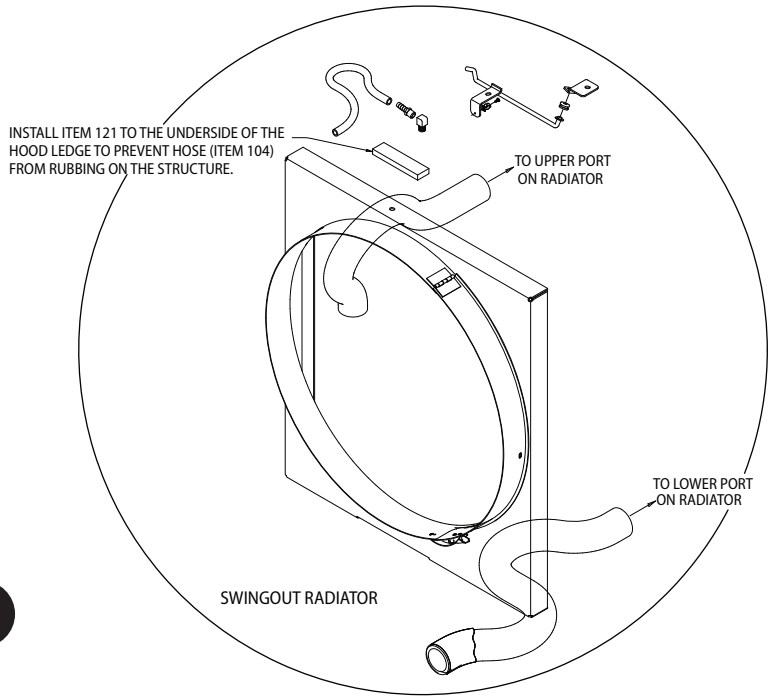
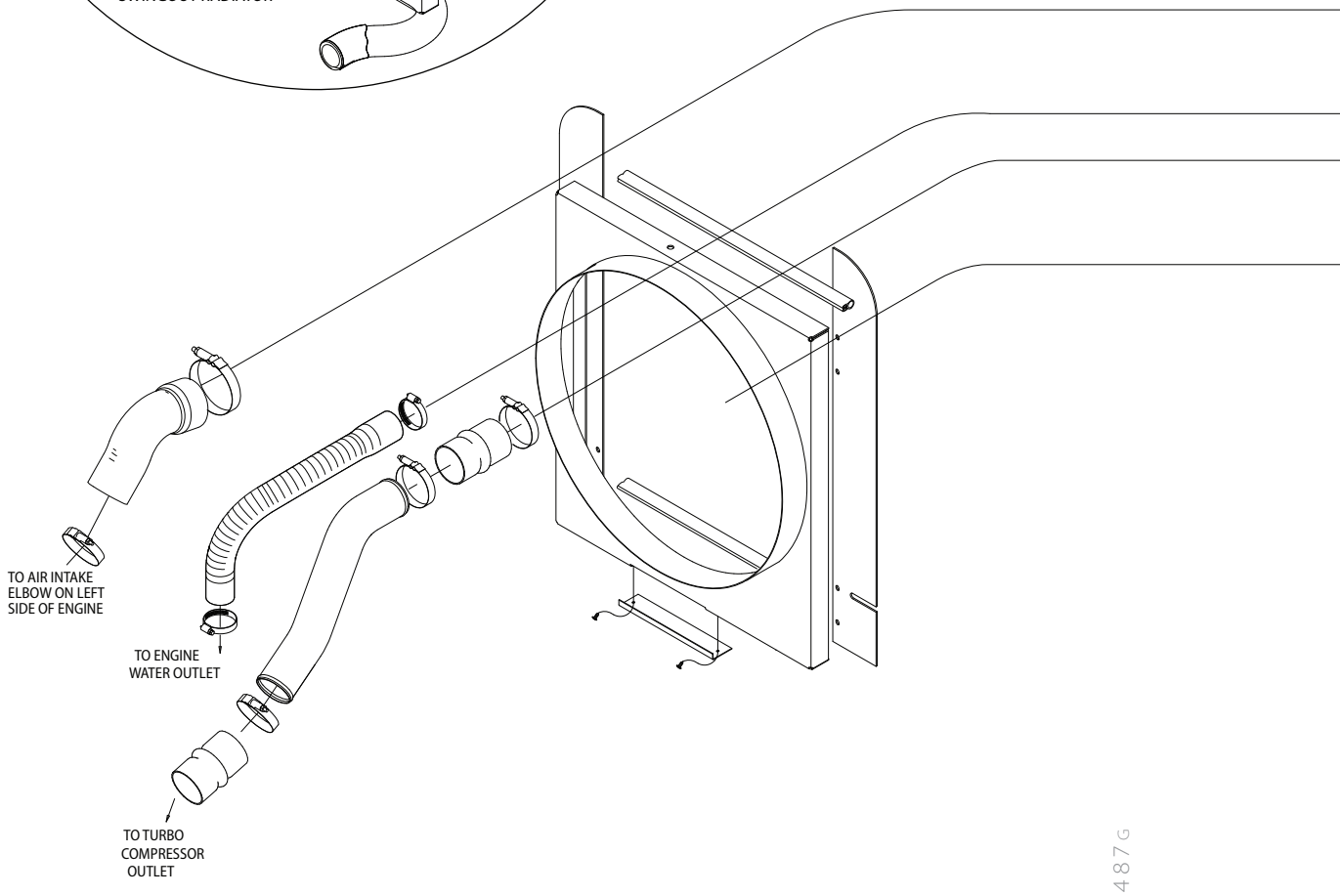
Cooling System: A3FE Cummins ISB-07 Hi Torq


NOTE: INSTALL TEFLON TAPE ON ALL THREADS ON PARTS THAT ARE INSTALLED IN THE SURGE TANK . USE PIPE SEALANT ON ALL OTHER PIPE THREADS.
SURGE TANK MOUNTING BRACKET IS A SUBPART TO THE FRONT STRUCTURE.
1.88±.06
CUT LINE
SCRAP
DETAIL "A"
USE FASTENERS SUPPLIED WITH FAN CLUTCH. TORQUE TO 20-25 FT/LBS.
TO ENGINE VENT
TO 3/4 PORT ON WATER INLET.
NOTE: COOLANT RECOVERY TANK MOUNTS IN FRONT OF RIGHT HAND OUTRIGGER. ALSO ITEM 12 IS NOT VISIBLE.
TO ENGINE WATER INLET
TRANSMISSION COOLER ASSY.





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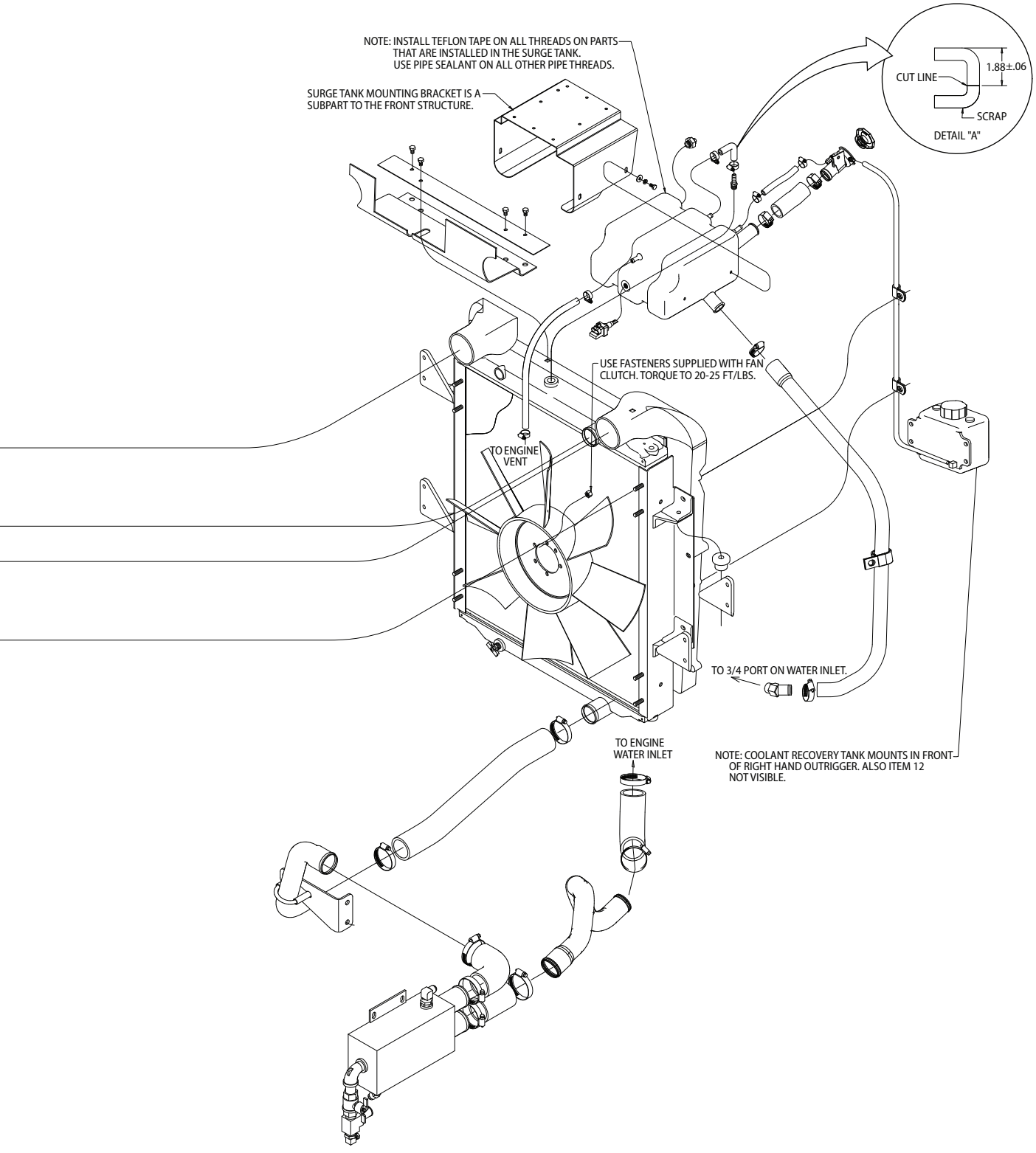
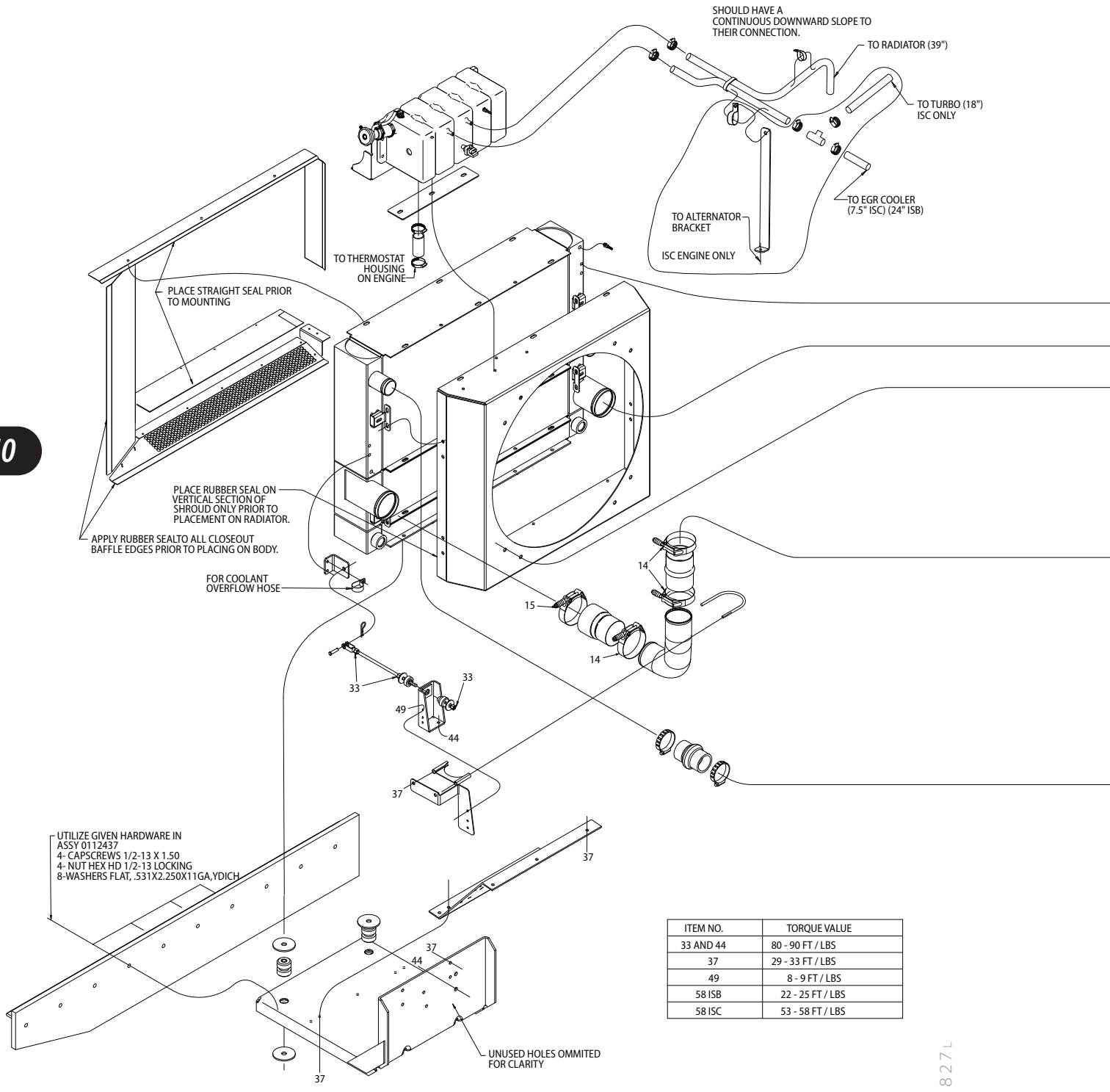
Cooling System: A3FE Cummins ISB-07 Lo Torq

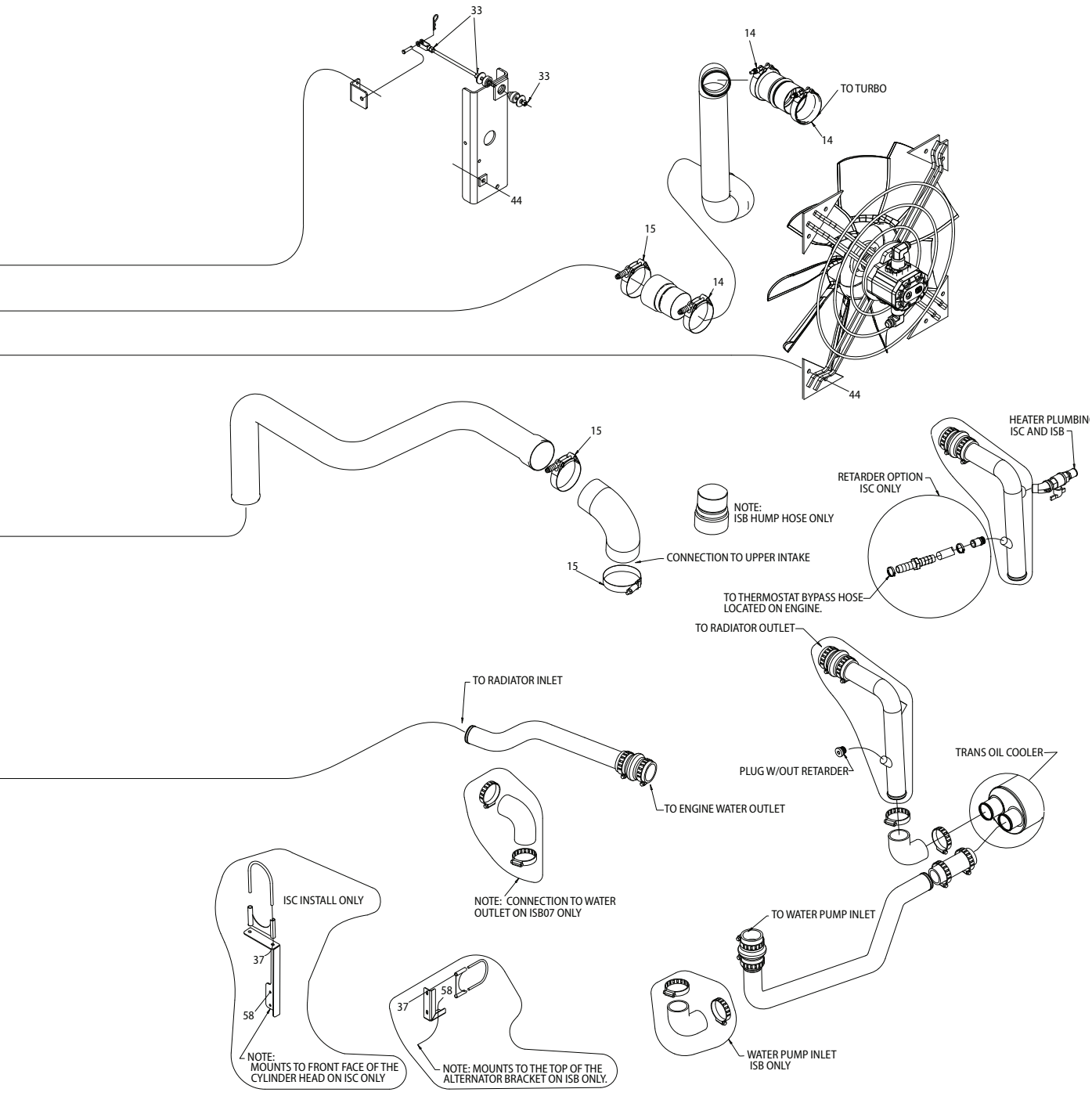

NOTE: INSTALL TEFLON TAPE ON ALL THREADS ON PARTS THAT ARE INSTALLED IN THE SURGE TANK. USE PIPE SEALANT ON ALL OTHER PIPE THREADS.
SURGE TANK MOUNTING BRACKET IS A SUBPART TO THE FRONT STRUCTURE.
CUT LINE
1.88±.06
SCRAP
DETAIL "A"
USE FASTENERS SUPPLIED WITH FAN CLUTCH. TORQUE TO 20-25 FT/LBS.
TO ENGINE VENT
TO 3/4 PORT ON WATER INLET.
TO ENGINE WATER INLET
NOTE: COOLANT RECOVERY TANK MOUNTS IN FRONT OF RIGHT HAND OUTRIGGER. ALSO ITEM 12 NOT VISIBLE.

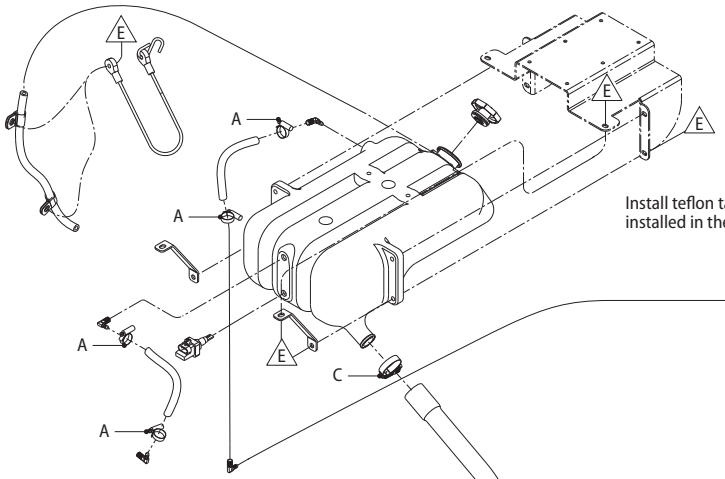


ITEM NO.	TORQUE VALUE
33 AND 44	80 - 90 FT / LBS
37	29 - 33 FT / LBS
49	8 - 9 FT / LBS
58 ISB	22 - 25 FT / LBS
58 ISC	53 - 58 FT / LBS

0111827L

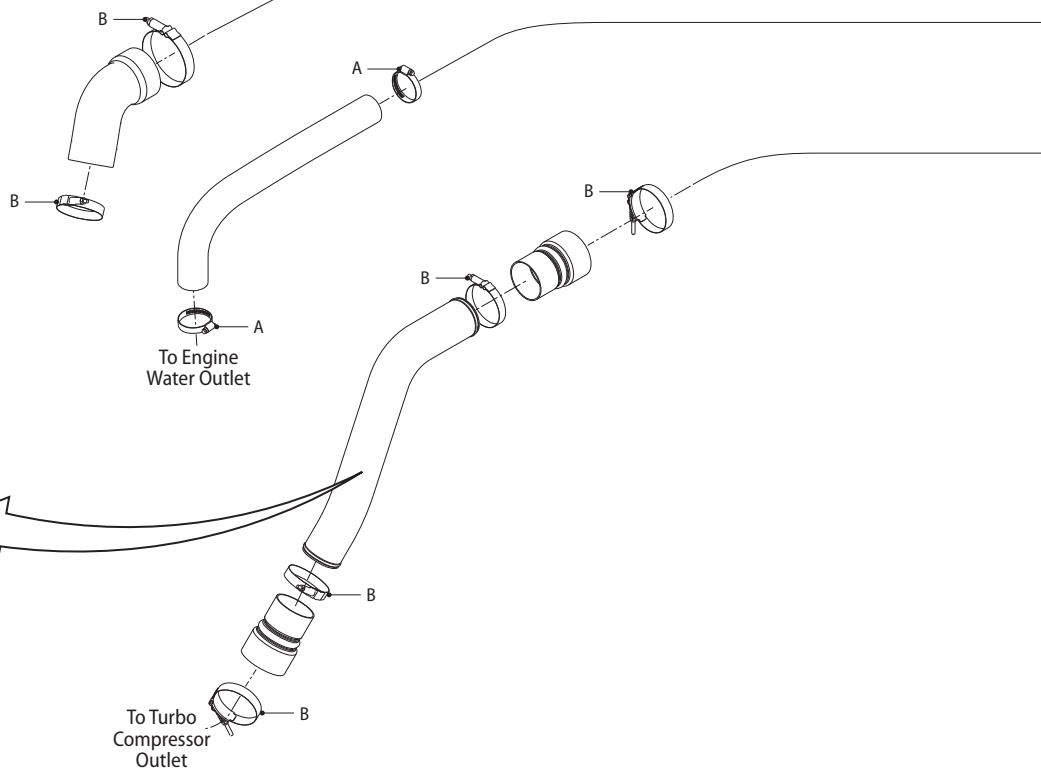
Cooling System: A3RE Cummins ISC-07 & ISB-07

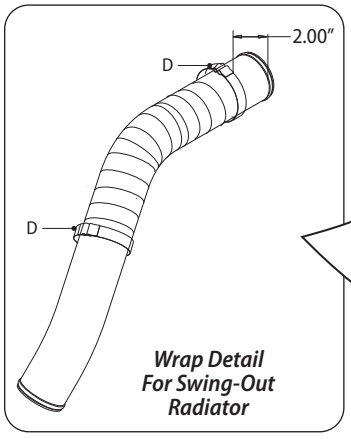

33
33
44
14
TO TURBO
14
15
14
44
15
15
CONNECTION TO UPPER INTAKE
NOTE:
ISB HUMP HOSE ONLY
RETARDER OPTION
ISC ONLY
HEATER PLUMBIN
ISC AND ISB
TO THERMOSTAT BYPASS HOSE
LOCATED ON ENGINE.
TO RADIATOR OUTLET
TO RADIATOR INLET
TO ENGINE WATER OUTLET
PLUG W/OUT RETARDER
TRANS OIL COOLER
NOTE: CONNECTION TO WATER
OUTLET ON ISB07 ONLY
ISC INSTALL ONLY
37
58
NOTE:
MOUNTS TO FRONT FACE OF THE
CYLINDER HEAD ON ISC ONLY
37
58
NOTE: MOUNTS TO THE TOP OF THE
ALTERNATOR BRACKET ON ISB ONLY.
TO WATER PUMP INLET
WATER PUMP INLET
ISB ONLY



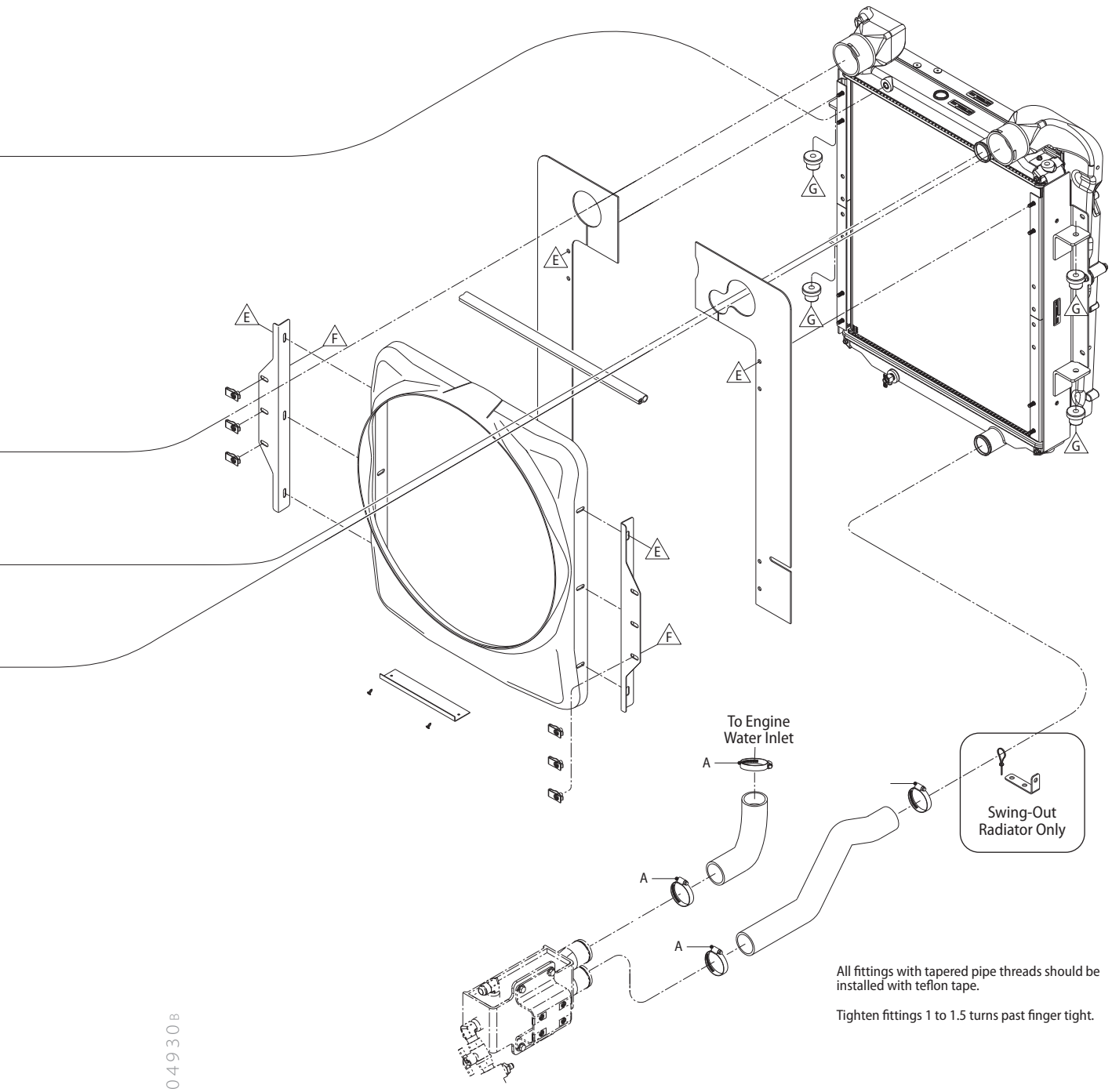
Install teflon tape on all parts installed in the surge tank.

Torque Specifications	
Item	Torque
A	7.50 - 8.30 ft.lbs.
B	5 - 5.80 ft.lbs.
C	3.75 - 5.50 ft.lbs.
D	3 - 4 ft.lbs.
E	18 - 20 ft.lbs.
F	25 - 30 ft.lbs.
G	80.00 ft.lbs.





Wrap Detail For Swing-Out Radiator



All fittings with tapered pipe threads should be installed with teflon tape.

Tighten fittings 1 to 1.5 turns past finger tight.

D0004930B

Cooling System: A3FE Cummins ISB-10

About Coolant

As emission and performance regulations become more stringent, the normal operation temerature range for turbocharged diesel engines increases. One of the consequences is that careful maintenance of the cooling system becomes increasingly critical in prolonging the life of the engine. At higher temperatures, relatively minor imbalances or impurities in the coolant can dramatially increase the potential for corrosion. Establish a disciplined and consistent regimine for monitoring and testing the coolant in your Blue Bird school buses. Keep accurate records, use only coolants recommended by the engine manufacturer. Change coolant within its specification lifetime and never mix different types of coolant.

Periodic testing and maintenance of the coolant should be performed in accordance to the engine manufacturer's specifications. Testing and maintenance procecures differ between standard-life and extended-life coolants. Locally available test strips may be used to test standard-life coolants. However, such test strips are not appropriate for long-life coolants; therefore long-life or extended-life coolants must be sample tested at qualified cooant laboratories. Because specification, recommendation, and terminologies differ among engine manufacturers, Blue Bird advises stictly adhering to the coolant maintenance specifications of the engine manufacturer. Carefully following the engine manufacturer's recommendations is the surest way to maintain compliance with engine warranties.

Beginning in January of 2007, Blue Bird implemented a program to simplify the coolant types installed at the factory.

Standard Equipment Coolant

Cummins Fleetguard ES Compleat 50/50 premix (blue in color) is installed as standard equipment with Cummins.

This coolant meets all specifications and requirements for extended-life coolant and is to be considered standard-life coolant when installed in Cummins engines.

Optional Extended Life Coolant

Cummins Fleetguard ES Optimax 60/40 premix (red in color) is installed in bus products equipped with Cummins engines when purchased with an option for extended-life coolant.

Note: *If you wish to convert from standard life coolant to Fleetguard ES Optimax extended life coolant, follow the guidelines set forth in the Fleetguard Maintenance Bulletin, MB1/04-1 at www.cumminsfiltration.com/pdfs/product_lit/americas_brochures/MB1-04-1.pdf.*

Coolant Filter

On all of the above-listed bus models equipped with an optional coolant filter, the same Wix replacement filter element cartridge is used:

Blue Bird Part Number: 0064641
Wix Part Number: 24070

The coolant filter should be replaced every 6 months or 6,000 miles; whichever occurs first.

Coolant Decals

On all of the above-listed bus models, Blue Bird installs a decal stating:

- The type of coolant installed at the factory.
- The coolant manufacturer's part number for one gallon quantity, suitable for regular top-off and refill.
- The coolant manufacturer's part number for one gallon quantity of the concentrate version of the installed coolant, suitable for formulating stronger glycol mixture ratio.

Blue Bird also installs a second decal containing radiator warnings. Both decals are mounted near the coolant fill neck.

Coolant Maintenance

Blue Bird advises strictly abiding by the following policy for all coolant maintenance for the life of the vehicle.

Never Mix Coolant Types

Routine coolant addition (top-off) must match the installed coolant type and brand. Do not mix coolants of different colors, types, or brands in the same engine.

Strictly Follow The Engine Manufacturer's Specifications

Each engine manufacturer publishes its own specific requirements for testing and maintaining coolant in their respective engines. Blue Bird recommends strictly abiding by the engine manufacturer's testing and maintenance schedules and draining, flushing, refilling procedures to maintain compliance with the engine warranty requirements. Blue Bird recommends that you maintain accurate vehicle-specific service records of all coolant system maintenance procedures performed.

For Cummins engines using Fleetguard ES coolants, send coolant samples to Fleetguard for Monitor C testing, as specified in the Cummins Operator's Manual. Label sample as Extended-Life coolant.

Note: *For more information on coolant testing tools see: www.cumminsfiltration.com/pdfs/product_lit/americas_brochures/LT15068.pdf.*

Always Mix Concentrate With Premix Coolant, Not Water

If concentrated coolant is added in order to raise the glycol ratio, use only the concentrate version of the same premix coolant type and brand as installed. Do not mix the concentrate with water. Instead, mix the concentrate with the premix version of the same coolant.

Only Add Tap Water In Emergency Situations

A regularly-scheduled bus inspection and maintenance program should be followed to prevent coolant losses due to damaged or worn hoses, loose clamps, etc.

If coolant is lost while the bus is in use, and roadside emergency measures are called for, replenish the coolant with the same premix type and brand if possible. If the proper coolant is not available, and water must be used, use only de-ionized water if possible. Ordinary tap water should only be used if proper coolant or de-ionized water are not available.

Whenever tap water alone has been added, the bus should be taken to a service facility and the entire cooling system should be completely drained, flushed, and refilled with premix coolant.

FACTORY INSTALLED COOLANTS

Cummins, Fleetguard ES Compleat

Blue in color. Standard equipment coolant in all D3FE, D3RE, BBCV.

Considered standard-life coolant in Cummins engines.

Concentrate version may be mixed with the pre-mix version to lower freezing point.

AVAILABILITY

50/50 Premix

1 Gallon Container

2 1/2 Gallon Container

55 Gallon Drum

330 Gallon Tote

Concentrate

1 Gallon Container

Cummins, Fleetguard ES Optimax

Red in color. Optional coolant in D3FE, D3RE, BBCV, with Cummins engines.

Qualifies as extended-life coolant in Cummins engines.

Blue Bird installs 60/40 premix, which is not available in one gallon containers, but is available in larger containers (listed).

The 50/50 premix may be mixed with the concentrate version per Fleetguard's instructions to achieve 60/40 ratio.

Concentrate version may be mixed with the pre-mix version to lower freezing point.

AVAILABILITY

50/50 Premix

1 Gallon Container

60/40 Premix

55 Gallon Drum

275 Gallon Tote

Concentrate

1 Gallon Container

Coolant Filter (Optional)

Your Blue Bird bus may be equipped with an optional Perry Coolant Filter, a separate filter assembly with a replaceable spin-on filter element. On All American Forward Engine buses, the filter is mounted to the left side of the engine block. On All American Rear Engine, the filter is mounted to the radiator brace mounting bracket at the left side of the engine compartment.

The entire volume of coolant does not pass through the filter on each cycle. Rather, the filter assembly is connected to two coolant ports on the engine block, effectively providing an "alternate path" for coolant to flow. As coolant circulates through the system, that volume which passes through the filter is cleaned of contaminates.

The filter mount is fitted with two shut-off valves. Closing both valves closes the inlet and outlet lines, to allow removal and replacement of the filter element without excessive coolant spillage. The amount of coolant lost is that contained in the volume of the filter element.

All American buses built during or after August, 2006, have one of three specific coolants installed at the factory (see Factory Installed Coolants in this chapter.) The same Wix replacement filter element cartridge is used for all three of the factory installed coolants:

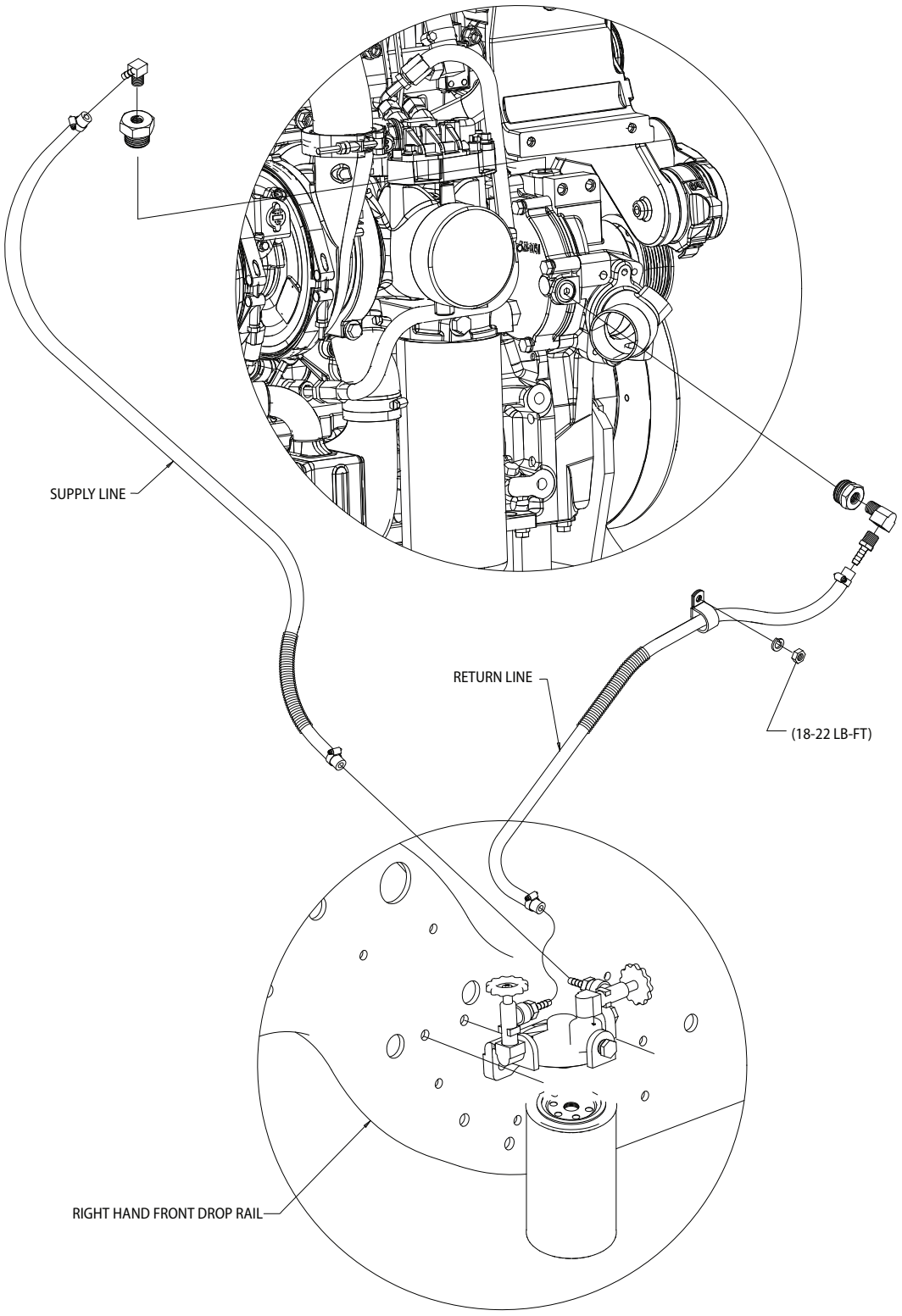
Blue Bird Part Number: **0064641**
Wix Part Number: **24070.**

Do not use coolant filter elements which dispense Supplemental Coolant Additives (SCAs) to the system.

Coolant Filter Element Replacement

The coolant filter should be replaced every 6 months or 6,000 miles; whichever occurs first.

1. Fully close both shut-off valves at the filter mount.
2. Remove the filter element by turning it counter-clockwise.
3. Fill a new filter element of the proper type for the coolant in use withi premixed coolant of the same type already in the engine. Install the new and filled filter element.
4. Open both shut-off valves.



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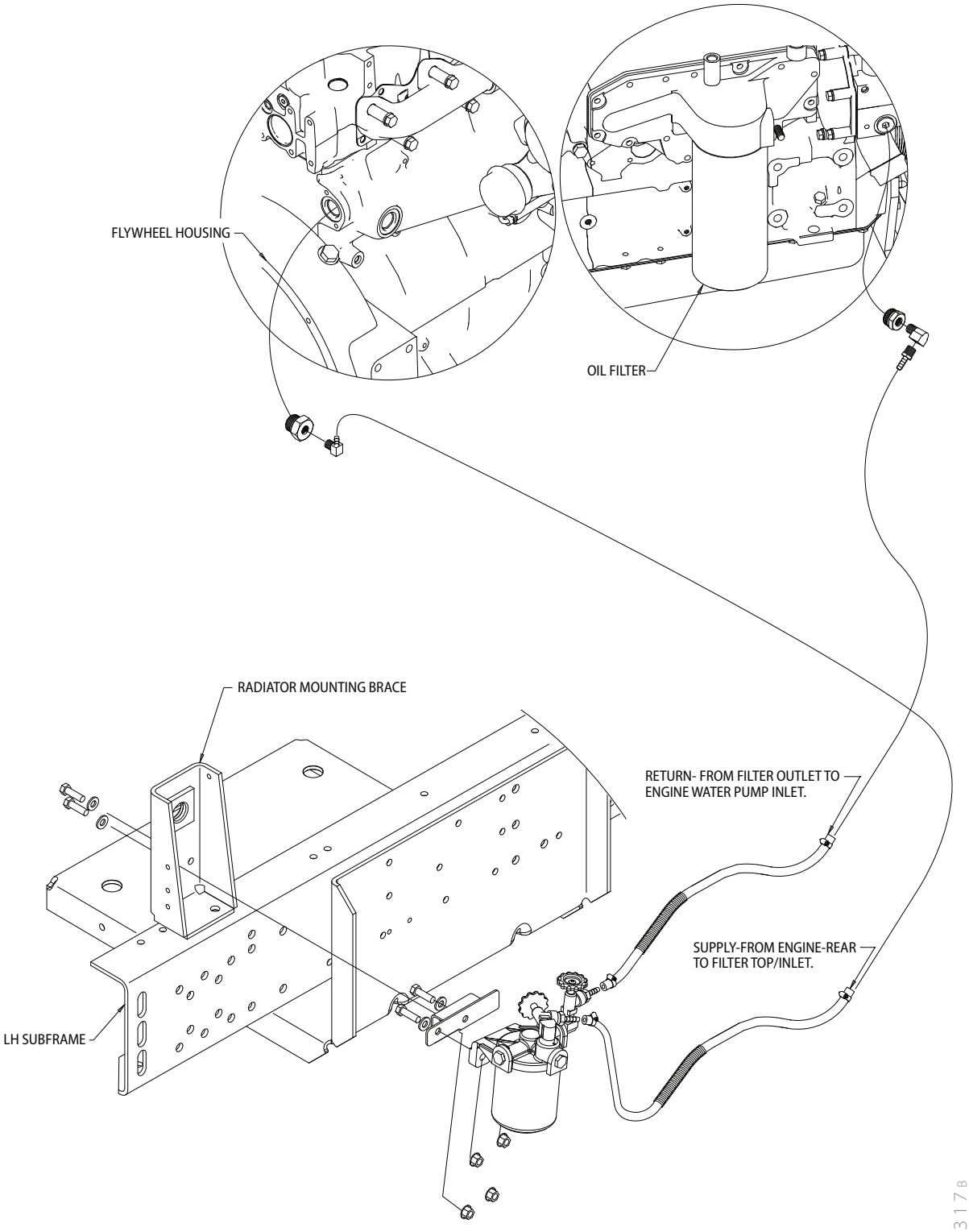
Coolant Filter: A3FE *Optional*



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Coolant Filter: A3RE *Optional*

Radiator Shutters

Your bus may be equipped with Radiator Shutters, a popular option on both Forward Engine and Rear Engine All American buses operated in colder climates. Shutters restrict ambient air passing through the radiator and over the engine, and thereby shorten warm-up time for the engine and passenger compartment heaters.

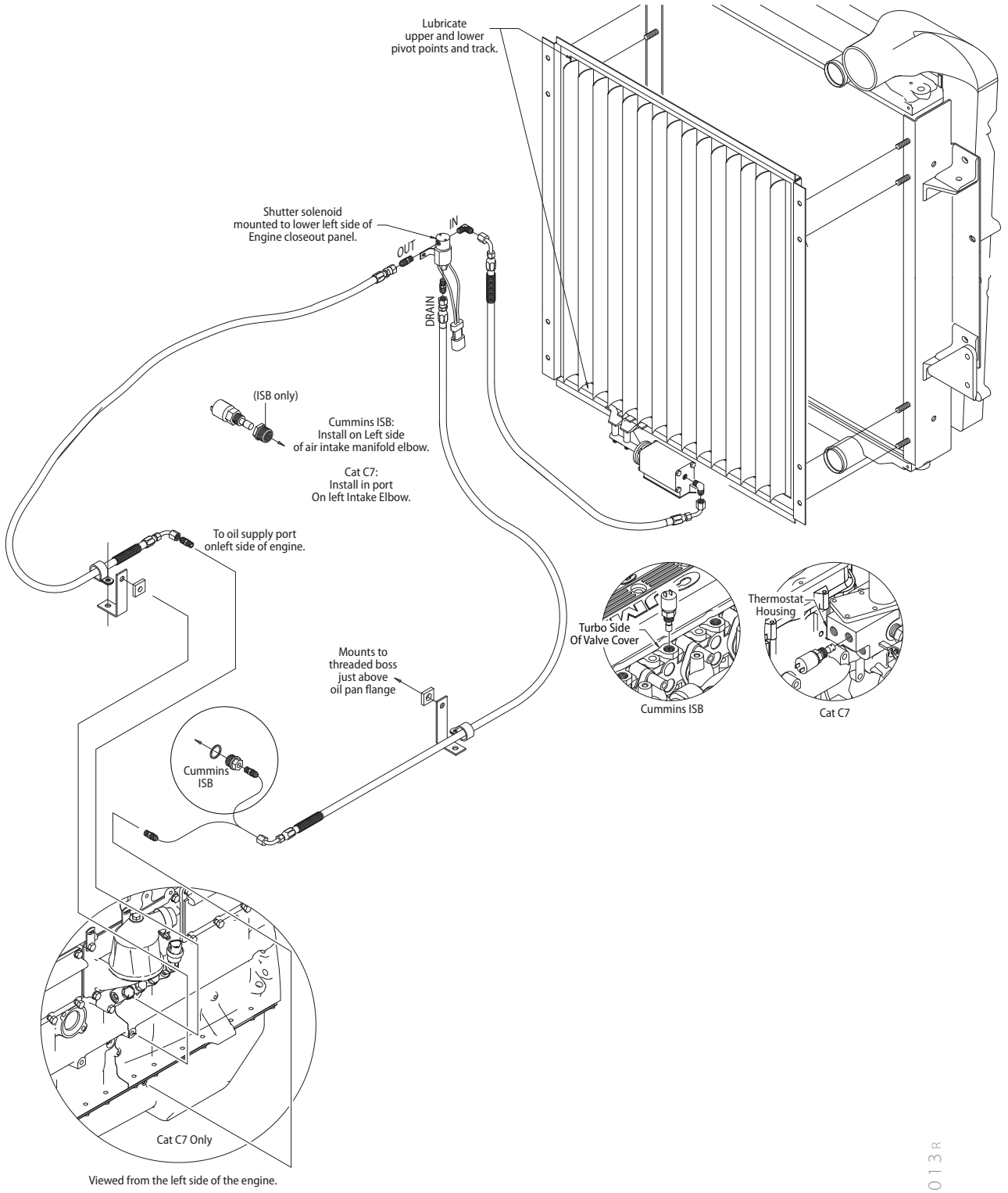
The Kysor Radiator Shutters unit is a window blind-like assembly of adjustable leuvers mounted on the fan-side of the radiator. The shutters are spring-loaded in a normally-open position. On buses equipped with air brakes, the shutter mechanism is closed at certain temperatures by an air cylinder, and on buses with hydraulic brakes, by an hydraulic actuator.

Unlike the radiator fan, shutters are not controlled by the engine ECU, but by their own independent circuit. Two temperature sensors—one mounted in the engine coolant circuit and the other in the intake tract of the Charge Air Cooler system—are wired in the Radiator Shutters control circuit. Both sensors are normally closed. When ignition is on, current passes through both sensors, and energizing the Shutter control solenoid to close the shutters. As the engine warms, one or both of the two sensors create an open in the circuit, de-energizing the shutter control solenoid and allowing the leuver vanes to open the shutters.

Air-powered shutter solenoids receive actuation air from a line leading directly to the supply (wet) air tank. When the solenoid opens, the air which was closing the shutters is expelled through the solenoid's exhaust port.

Hydraulically-powered shutter solenoids receive engine oil from a line leading from an oil supply port on the left side of the engine. When the solenoid opens, the oil which was closing the shutters is returned to the engine sump through the solenoid's drain line.

Shutters should be inspected regularly and kept free of obstructing debris. The pivot points of the leuvers and their linkages should be lubricated periodically with a light spray lubricant such as WD40 or a graphite spray.



Shutters, Hydraulic: A3FE *Optional*

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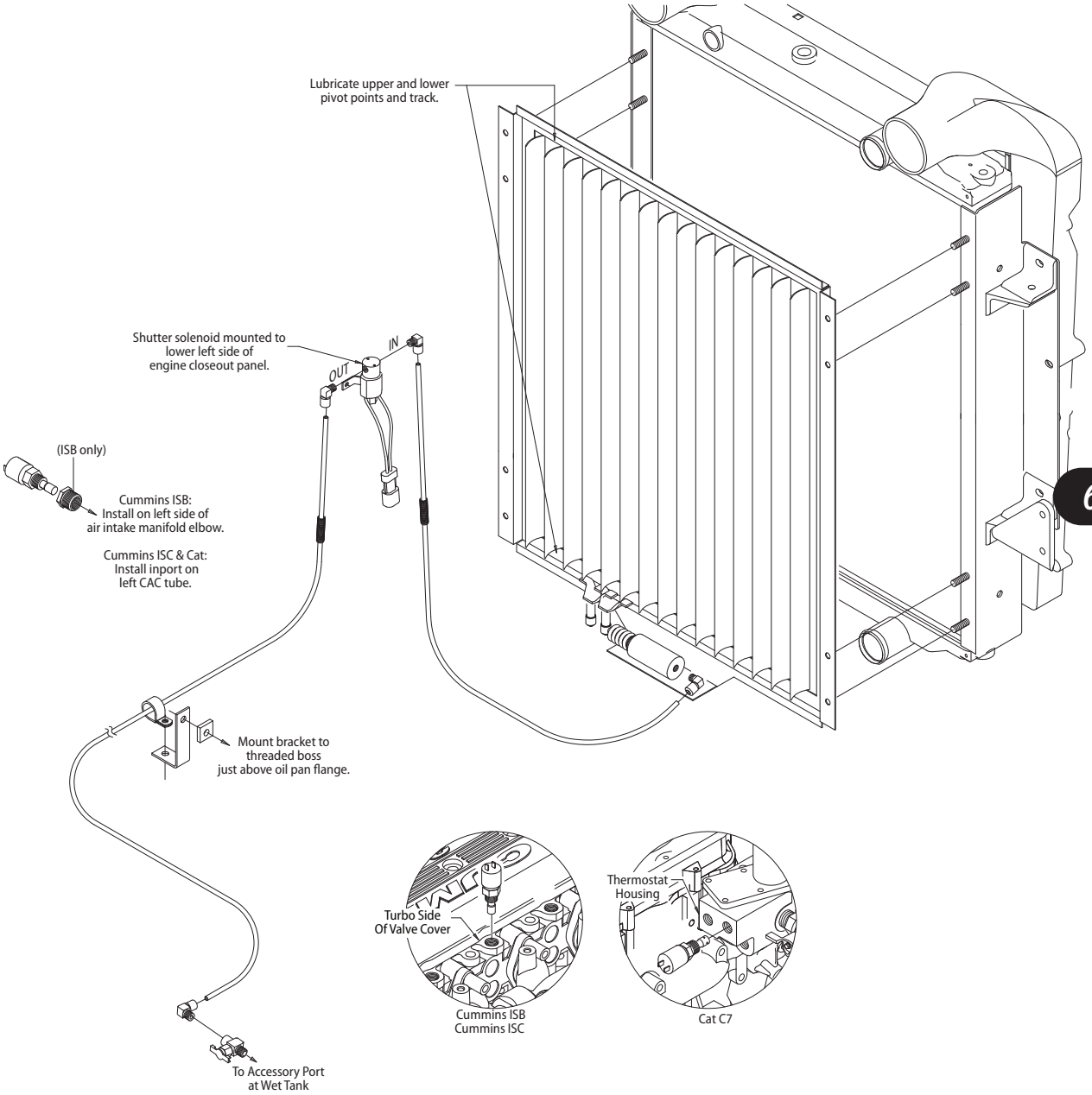
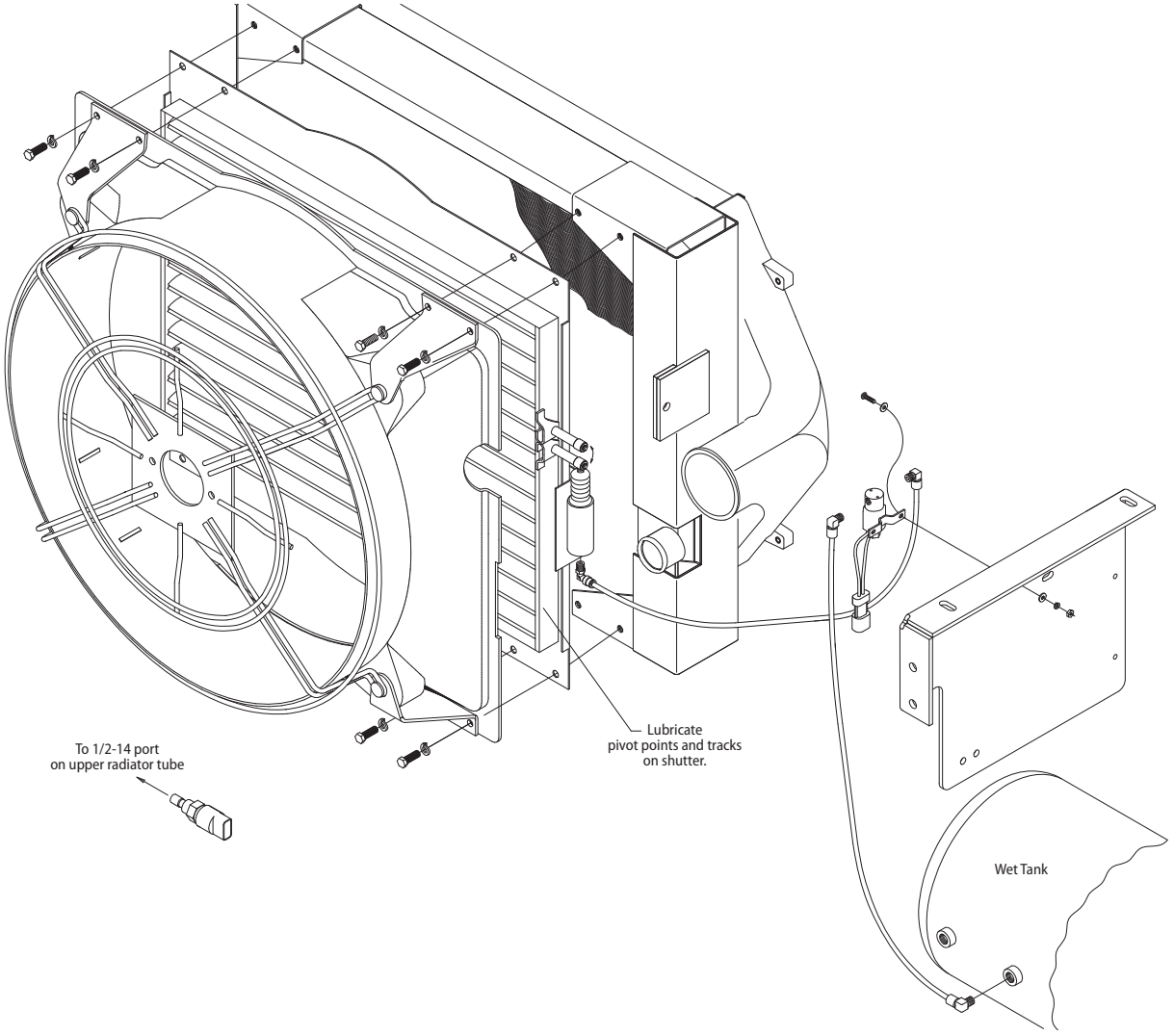


Shutters, Air: A3FE *Optional*



0006617E

Shutters, Air: A3RE *Optional*

Radiator

On both All American Forward Engine and All American Rear Engine buses, the radiator is pre-assembled to a similarly-constructed Charge AIr Cooler; however, other than being assembled and mounted as a combined "cooling pack", the two units serve two separate circuits and do not directly interact. While the radiator serves to remove heat from the circulating engine coolant, the Charge Air Cooler removes heat from the engine intake air. Both perform their functions by passing ambient air drawn by the radiator fan across tubing coils which contain coolant (in the radiator) or filtered intake air (in the Charge Air Cooler). The thin corregated fins of each unit conduct heat from the internal coils and thereby disperses it across a broad surface area, allowing it to be carried away by the flow of air.

See the Intake chapter for a more complete functional description of the Charge Air Cooler system. In the descriptions below, references to "the radiator assembly" refer to the combined cooling pack, since the radiator and CAC are handled as a unit. If the bus is equipped with optional radiator shutters, the shutters unit is also attached to the radiator, and all three components are removed and installed together.

Swing Out Radiator

On Forward Engine All Americans, servicing components at the front of the engine and behind the radiator assembly, such as pulleys, water pump, fan belt, fan clutch, air conditioner compressors, or radiator shutters may require removal of the radiator. A popular option on Forward Engine units, therefore, is a special set of parts which allow the radiator to be pivoted slightly without disconnecting coolant hoses and draining coolant.

The actual mounting of the radiator unit itself is very similar between the standard installation and that of the swing out radiator option. The components which differ are:

- Longer coolant hoses to allow the necessary flexibility at the right side of the radiator.
- The fan shroud flange is fitted with a release clasp to provide clearance from the fan blades when the radiator is pivoted.
- A set of slotted bumper brackets which allow the bumper to pivot downward without complete removal.

Radiator Removal, All American Forward Engine

The following radiator removal procedure is illustrated with a bus which has the swing-out radiator option. Differences between this and the standard installation are noted in the procedure text. To remove the radiator:

1. Completely secure the bus against accidental movement. Remove the ignition key. Chock all wheels. Disconnect the positive battery terminals (or turn off the master power switch if so equipped.)

2. Pivot or remove the front bumper:

   2.1 Remove the stepwell rock guard plate bolted between the bottom right flange of the bumper and the forward edge of the stepwell. (5 bolts, washers, nuts).

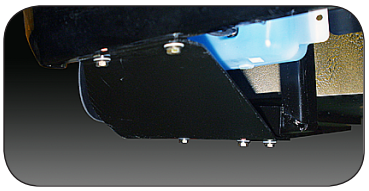
   2.2 Look inside the bumber openings at the mounting brackets just above the tow hooks. If the top bracket bolt is mounted in a curved slot of the brackets, the bumper is a pivoting bumper. On each side, loosen the bolt in the curved slot. Then loosen the bottom bolts. If the brackets are not slotted, remove the four bolts completely and remove the bumper. (Tip: If the bus is equipped with a pivoting bumper, it serves as an effective "parts tray" for fasteners throughout the procedure."

3. Remove the front grille panel:

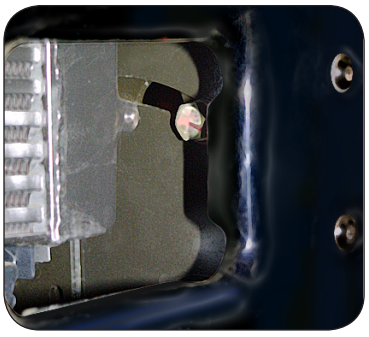
   3.1 Open the hinged grille panel. Spread one closed end of the S-hook at the upper end of the support cable to unlatch it from the bracket. Then close the panel.

   3.2 Remove the four phillips screws (two on each side) between the slots of the lower portion (below the hinge) of the front grille panel.

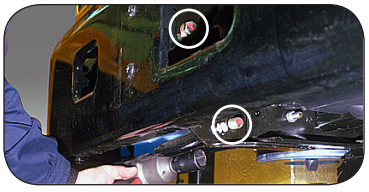
   3.3 Open the hinged panel. Carefully lift the grille assembly upward and away from the bus.



Rock guard plate



Sloted bracket on pivoting bumper



Two bolts pers side for bumper pivoting/removal

Pivoting bumper

Four grille mounting screws

Grille removed.

4. Remove the cross bar which spans the radiator opening near the bottom of the radiator. (Four bolts, washers, lockwashers, and nuts.)

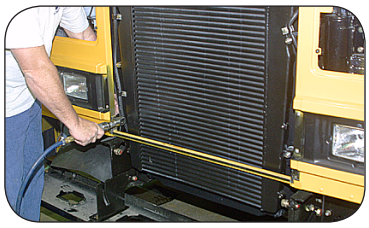
5. Inside the bus, remove the engine cover and housing:

   5.1 Open the hinged cover. Remove the bolt, lockwasher, and nut which secures the bottom end of the support cable.

   5.2 Unlatch the five clasp latches which secure the cover housing.

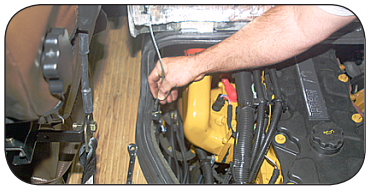
   5.3 Being careful to separate the rubber gasket from the opening surrounding without damaging it, lift out and remove the whole engine cover assembly.

6. Loosen CAC tubes: Loosen the rearmost clamp of the red flex tube which connects the left CAC pipe to the engine intake elbow. Similarly loosen the rearmost clamp of the right-side CAC pipe. Push forward on the flex tubes to make sure they are unstuck and can slip off when the radiator is removed.

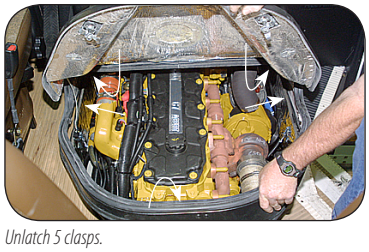


Remove 4 bolts, washers, nuts from crossbar.

Open the hood.

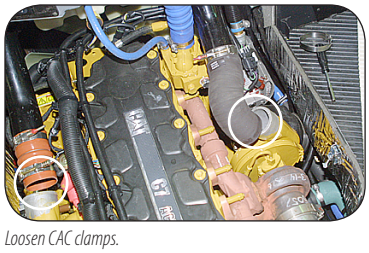


Disconnect support cable.



Unlatch 5 clasps.

Close hood. Lift out as a unit.



Loosen CAC clamps.

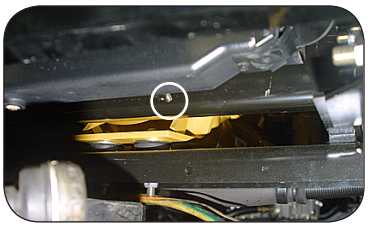
7. If the radiator is not equipped with the pivot option, drain the coolant:

   7.1 Position a clean receptacle under the petcock drain at the bottom of the radiator. Remove the filler pressure cap. Open the petcock drain. (Tip: After draining at the petcock stops, it is often helpful to also loosen the lower radiator hose clamp and insert a screwdriver between the hose and the radiator. This allows additional coolant to drain from the dip in the lower hose.)

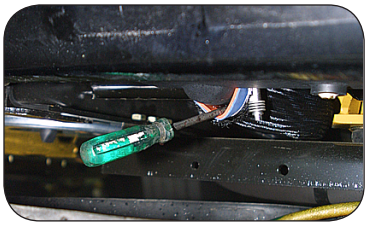
   7.2 Disconnect the radiator hoses: Loosen the deaeration vent hose clamp at the top of the radiator and push the vent hose end off the radiator. Loosen the upper and lower radiator hose clamps and push the hoses back enough to ensure they are unstuck and will slip off when the radiator is removed.

8. Remove the harness clamp bolts which secure the harness along the driver's side of the radiator.

11. If the bus is equipped with the pivot radiator feature, release the clasp at the lower left of the fan shroud. This lets the shroud expand slightly to provide needed clearance with the fan when the radiator hinges.

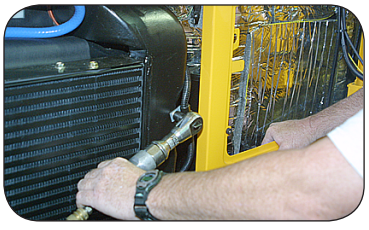


Radiator drain petcock



Bottom radiator hose

Disconnect radiator hoses after draining. Not necessary on buses equipped with pivot radiator feature.



Remove the harness clamps from the radiator and push the harness out of the way.

(Viewed from under the radiator.) On buses with pivoting radiators, a clasp on the right side of the fan shroud allows it to expand to provide clearance from the fan blades when the radiator is pvioted.

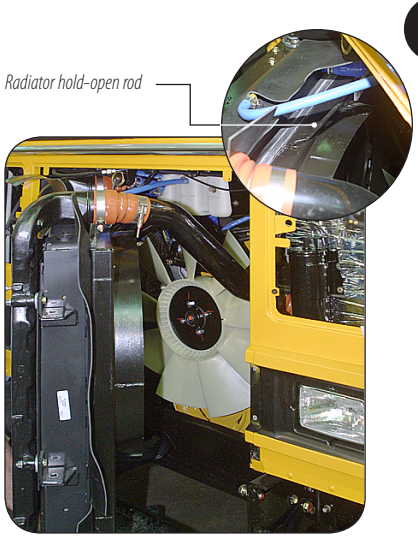
12. The radiator assembly is mounted on four rubber-cushioned mounts, two on each side. If the bus is equipped with the pivot feature, remove only the fasteners on the driver side, and only loosen the fasteners on the curbside. These will serve as hinges when loosened. Pull outward on the driver side of the radiator to hinge it outward. Ensure that the Driver-side CAC tube does not snag. Hinge the radiator far enough to insert the hold-open rod mounted above the radiator into the hole in the top of the radiator.

13. If the bus is not equipped with the radiator pivot feature, completely remove all four mounting bolts, eight washers, and four nuts. With an assistant, lift the radiator forward and away from the bus. As the radiator is pulled out, support the CAC pipes with one hand, with the other hand under the bottom of the radiator.

Loosen all four radiator mount bolts. On pivoting radiators, remove only the driver side two. On non-pivoting radiators, remove all four.

Reassembly

Having the radiator removed or hinged provides access to engine front components. After the service procedures are complete, reinstall the radiator, bumper, rock guard, CAC tubes and grille in reverse order of the removal proceure outline. If the coolant has been drained into a clean recepticle, and if it is still within its service life, it may be reinstalled. After refilling, bleed the heater system to remove trapped air and ensure that the coolant level is topped-off to the proper level.



Pivoted radiator provides engine front access without draining coolant.

Obtain assistance in lifting out non-pivoting radiator.

Cooling System Drain, Flush & Refill

The following is a general procedure for complete coolant change (drain, flush, refill). Blue Bird recommends that an authorized Caterpillar, Cummins, and John Deere dealer/distributor perform this flush and fill in their respective engines. If there are differences between the information in this procedure and the engine manufacturer's Operator's or Maintenance Manuals, follow the engine manufacturer's instruction.

1. Drain the cooling system:

   1.1 Park bus on a level surface, apply parking brake, turn off engine, remove ignition key and chock wheels.

   1.2 Allow the engine to cool. Then remove the radiator cap. Locate and open both heater hose cut-off valves. Open all heater control valves fully. Removal of the thermostat may assist in draining, flushing, rinsing and refilling process. Follow engine manufacturers' recommendations on thermostat removal and installation.

WARNING ***Coolant released under pressure can cause serious burns. Remove filler cap only when cool enough to touch with bare hands. Slowly loosen cap to first stop to vent pressure before fully removing. Engine coolant is toxic and is an eye and skin irritant. Protective gear should be worn when working with coolant. Allow the system to cool before draining and flushing. Engine coolant is a threat to the environment. Use suitable containers for disposal. All applicable federal, state, and local laws must be observed when disposing of engine coolant.***

   1.3 Place a drain pan under the radiator drain and open the drain petcock. Drain and discard the coolant from the cooling system following all applicable federal, state, and local laws governing disposal of engine coolant. Be sure that all the heater valves are open in order to completely drain the engine, heaters, coolers, hose, etc.

   1.4 After system has drained, disconnect both the pressure and return heater hoses. Using a shop air hose set at a maximum of 15 PSI, blow air into the heater hoses to blow the remaining coolant from the heater system.

   1.5 Open the lowest coolant drain port or plug from the engine to drain any remaining coolant from the engine.

   1.6 Close all drains, reconnect heater hoses, and reinstall all plugs that have been opened or removed.

   1.7 If the system has a coolant filter, close the valves to the filter and remove the filter element.

1.8 On All American Forward Engine Only: If the system has any material collected on the cap, neck or deaeration tank, remove and replace the radiator cap (1325430), brass neck (0033762), and plastic deaeration tank (0032865). If the system has discolored coolant, inspect the cap, neck and deaeration tank for accumulation of foreign material or staining. If stained, clean the components. If the stain cannot be removed, replace the components. If the coolant is not discolored, and there is no accumulation on theses components, do not replace these components.

1.9 Reconnect all hoses that were disconnected while replacing components. Check all hose connections and clamps.

1.10 If the thermostat has been removed in an earlier step, reinstall thermostats following engine manufacturer's procedures.

2. Clean the Cooling System. Follow the engine manufacturer's instructions for chemically cleaning the entire cooling system.

On Caterpillar engines: If sludge or oil is evident,, use Caterpillar's 30-Day cleaner. For scale or deposits, use Caterpillar "Quick Flush" type cleaner.

On Cummins engines: If sludge or oil is evident, Use Fleetguard Restore. For scale or heavy metal deposits, use Fleetguard Restore Plus (+).

2.1 After the engine has been stopped and the cooling system has cooled, drain the cleaner from the entire system following the steps describe in the initial drain including blowing the system with 15 PSI (max) of shop air.

2.2 Close all drains and reconnect all hoses that have been removed.

2.3 Fill the system with fresh water and run for minimum of 30 minutes on high idle with heater pumps on and all heater valves open.

2.4 After the 30 minute (minimum) run, stop the engine and allow it to cool. Then drain the water from the entire system following the steps describe in the initial drain, including blowing the system with 15 PSI (max) of shop air.

2.5 With the hoses disconnected and the drain valves open, run fresh water through the heater system, radiator, transmission cooler and engine until the water is clear.

2.6 Repeat steps 2.2 thru 2.5 as many times as required to ensure that the system is clean and the chemicals are completely removed.

CAUTION ***After having used cooling system cleaners, be sure the systems are flushed 3–5 times to remove all cleaner from the system. If cleaner is not completely removed, ammonia salts will be left from the cleaner and severe copper corrosion can occur.***

3. If the bus is equipped with an optional coolant filter, check the filter head, clean filter head and lines as required to remove all of the old coolant and any residue. Install a new coolant filter element.

4. Refill the cooling system with coolant recommended by the engine manufacturer. Read the About Coolant section of this chapter thoroughly for information about the coolants installed at the Blue Bird factory, and for Blue Bird recommendations. Blue Bird recommends using only pre-mixed coolant, or mixing of premixed coolant with concentrate of the same type and brand (as opposed to mixing concentate with water) to raise the glycol ratio above that of the premixed coolant. Blue Bird recommends always topping-off coolant with the same pre-mixed coolant as is installed, rather than topping off with water. If water is used for top-off, use only deionized water. Never add tap water to the cooling system unless absolutely necessary in roadside emergency situations. Never mix coolants of different color, type, or brand. Keep accurate records of all coolant changes and maintenance.

5. Bleed Air From the Cooling and Heater System:

   5.1 Fully open the pressure-side heater hose cut-off valve. Fully close the return-side heater cut-off valve (located near the transmission cooler).

   5.2 In the Driver's area, open all heater temperature controls to their full on position, and turn on all heater pumps. The number of heater controls, and the presence of heater pumps depends upon optional equipment purchased on the bus.

   5.3 With the engine stopped and a cool engine, remove the radiator cap.

   5.4 On All American buses, locate the ¼" bleeder tube which is located near the deaeration tank. The bleeder tube originates from a low point of the cooling system, where the return heater hose returns coolant to the transmission cooler; and runs to a location near the deaeration tank.

   On All American Forward Engine buses: Open the front grille panel. The bleeder tube is tucked horizontally along the top of the radiator. Pull out the bleeder hose and insert its free end into the open filler neck of the deaeration tank. Then open the in-line bleed valve fully. During bleeding, overflow coolant will be returned directly to the deaeration tank.

On All American Rear Engine buses: The bleeder tube is located underneath the deaeration tank and its end is already connected to the to the tank. Open the in-line bleed valve fully. During bleeding, overflow coolant will be returned directly to the deaeration tank.

5.5 Start engine and operate at 1800 to 2000 rpm. Watching the coolant temperature gauge, ensure the engine reaches 180-190 degrees, the temperature at which the engine's thermostat normally fully opens.

5.6 Operate the engine with the bleeder valve open until all air has been purged from the system. During this time, monitor the level of coolant in the deaeration tank sight glass. As air trapped in the system escapes, the coolant level will occasionally rise and drop. Top-off the coolant level with pre-mixed coolant whenever it drops below the full level mark.

5.7 Air has been fully purged from the system when the coolant level no longer fluctuates, and the stream of coolant from the bleeder hose is constant. This may take 15-30 minutes.

5.8 After the air has been purged and solid stream is present, allow the engine to return to idle to cool down gradually. Close the bleeder valve and store the bleeder line in its original position.

5.9 Install the radiator cap.

5.10 Operate the engine until the thermostat opens. Then stop the engine and let it cool for 15-30 minutes. Check the entire cooling and heating system for leaks. Recheck coolant levels and top off with the same premixed coolant as is installed.

5.11 Obtain a coolant sample from the radiator drain petcock, and test the glycol level with a refractometer to ensure the glycol level is 50% minimum. If the glycol level is less than 50%, drain the appropriate amount of coolant and add concentrate per the engine manufacturer's instructions for increasing glycol percentage to correct level.

5.12 Pressure test the cooling system for leaks. If no leaks are found, the bus may be returned to normal service.

Fan Clutch, All American Forward Engine

During normal running, engine temperature is regulated by controlling the cooling effectiveness of the radiator. This is accomplished by powering and de-powering the fan which draws ambient air over the coils of the radiator.

On All American Forward Engine buses, the fan is mounted to an electromagnetic clutch mechanism. The outer housing drum of the fan clutch is a pully driven by the fan belt, and rotates whenever the engine is running. The fan blade assembly is mounted to the inner rotor of the fan clutch. An electromagnetic mechanism within the fan clutch assembly engages/disengages the inner rotor with the outer drum, and also serves to "cushion" the initial shock of engagement.

The engagement and disengagement of the fan clutch is controlled by the engine ECU. The ECU electronically monitors a signal it receives from a temperature sensor mounted near the engine coolant outlet. When the temperature signal reaches a pre-defined value, the ECU provides 12V current to engergize the fan clutch. The clutch engages and the fan blades are driven at engine speed, drawing more air through the radiator.

When the fan clutch is de-energized, the collapsing magnetic field momentarily induces a current with reversed polarity in the stator. The electrical connector of the fan clutch contains a diode which provides the induced current a low-resistance path to ground, to protect other circuits from being affected.

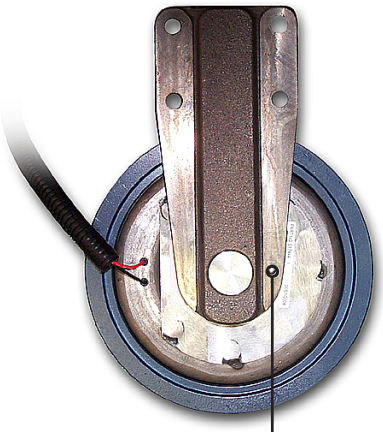
Reinstallation

Reinstall in reverse order of the removal procedure, observing these requirements:

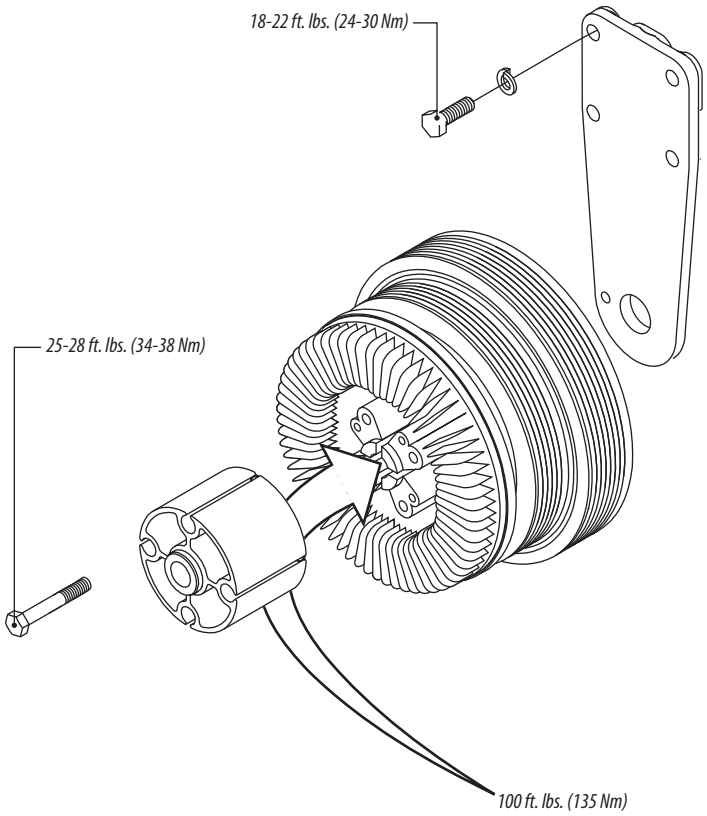
1. If the fan clutch assembly has been removed from the mounting bracket, be sure to align the anti-rotation boss on the mounting side of the fan clutch with the hole on the bracket:

2. Use these torque values when reassembling:

Journal Shaft to mounting bracket:	100 ft. lbs. (135 Nm.)
Fan mounting bolts to clutch hub:	25-28 ft. lbs. (34–38 Nm.)
Mounting bracket bolts to engine:	18-22 ft. lbs. (24–30 Nm.)



Be sure the anti-rotation boss aligns with the hole in the mounting bracket.



Hydraulic Fan Drive, All American Rear Engine

The cooling system on an All American Rear Engine is similar to that of an All American Forward Engine in respect to coolant flow between the engine and the radiator. Heat created by the engine will transfer to the coolant as the coolant flows through the engine and then to the radiator. A fan is used to create air flow across the outer surface of the radiator fins allowing the heat in the coolant to transfer into the moving air. This cycle of engine coolant absorbing heat from the engine and discharging heat at the radiator is very similar for both products. The major difference between the two products is how the fan creating the air flow across the radiator is driven. The fan on an All American Rear Engine is driven by a hydraulic motor rather than by a belt.

The hydraulic system that drives and controls the engine cooling fan shares some of its components with the steering system creating an integrated hydraulic fan drive/steering system.

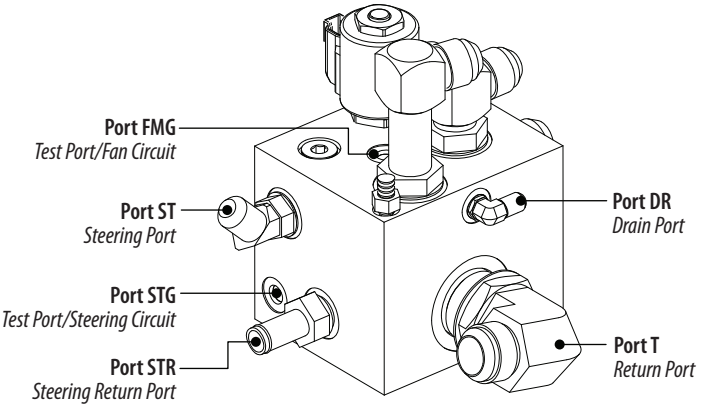
Oil for the hydraulic system is supplied by a vented reservoir located in the upper right area of the engine compartment. Two supply lines connected to the bottom of the reservoir provides an adequate supply of clean oil to the pump. The pump housing incorporates a two stage gear type pump configuration of equal displacement. Each stage of the pump has its own supply port and delivery port. The stage of the pump furthest from the mounting flange is the primary stage and provides oil flow to the steering circuit. The secondary stage, closest to the pump mounting flange, supplies oil for the fan circuit. The pump is gear driven by the engine power train and creates equal oil flow from each stage of the pump when the engine is running. Oil from both stages of the pump will flow through separate hydraulic hoses that connect to steering circuit supply port and the fan circuit supply port on the control valve.

The control valve is an integrated design consisting of an aluminum manifold with an integral fan control solenoid valve, two pressure control valves and a steering circuit flow control valve. Internal of the manifold the flow control valve receives its supply of oil from the primary stage of the pump through the steering circuit supply port (P2). The valve regulates the flow of oil available to the steering circuit to 4 gallons per minute (GPM). Having satisfied the steering circuit flow requirements the remaining oil flow from the primary stage of the pump will combine with the oil flow from the secondary stage of the pump, internal of the manifold, as it enters the fan circuit supply port (P1). A cartridge style pressure control valve monitors steering circuit pressure and will open the steering circuit to the reservoir return port (T) when excessive pressures occurs in the steering system. The returning oil form the steering gear will flow back to the control valve, through the steering return port (STR).

Oil flow entering the control valve through the fan circuit supply port (P1) from the secondary stage of the pump will combined, internal of the manifold, with the excess oil from the steering circuit. The combined oil flows through the fan port (FM) on the control valve to the inlet port of the fan motor. Unlike the steering circuit the fan circuit does not have a flow regulator valve. The oil flow available for the fan circuit is subject only to pump speed. The higher the RPMs of the pump the more oil flow the fan circuit will receive. It is important to understand that fan speed is directly proportional to the rate of oil flowing through the fan motor. Therefore, one of the two controlling factors of fan speed is how fast the pump is running which is directly related to engine speed.

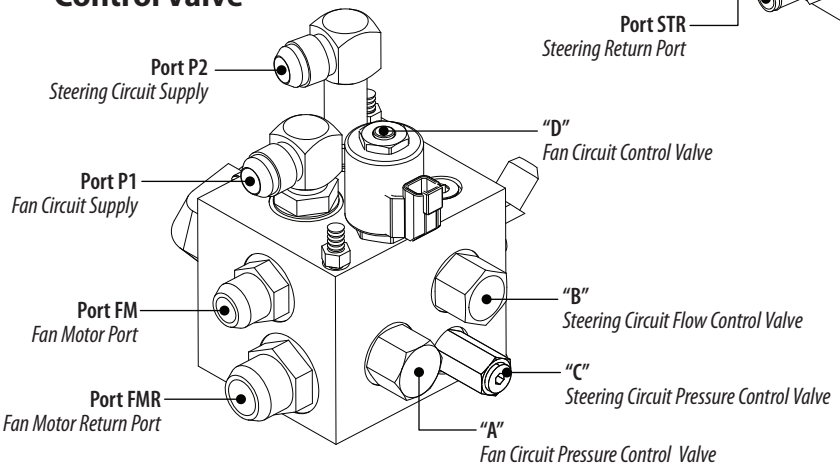
The fan circuit incorporates two control valves which working together provides two functions that govern the fan circuit. The cartridge style, pressure differential poppet control valve and the cartridge style pilot operated solenoid valve work together to monitor fan circuit pressure and engine cooling requirements. If excessive pressure occurs in the fan circuit the valve will open the fan circuit to the reservoir return port (T) lowering the pressure to a normal operating range. The second function the valves provides is a means of controlling fan speed according to the cooling requirements of the engine. When the engine ECM senses the engine coolant temperature or the charge air temperature is reaching a set point and cooling is needed, a pulse width modulation (PWM) signal will be sent to the fan control solenoid valve. The nature of the PWM signal drives the solenoid valve to vary the flow of oil to the fan motor thus varying the fan speed according to engine cooling requirements. The returning oil from the fan motor will flow through the hydraulic oil cooler, located below the radiator, and back to the control valve, through the fan motor return port (FMR).

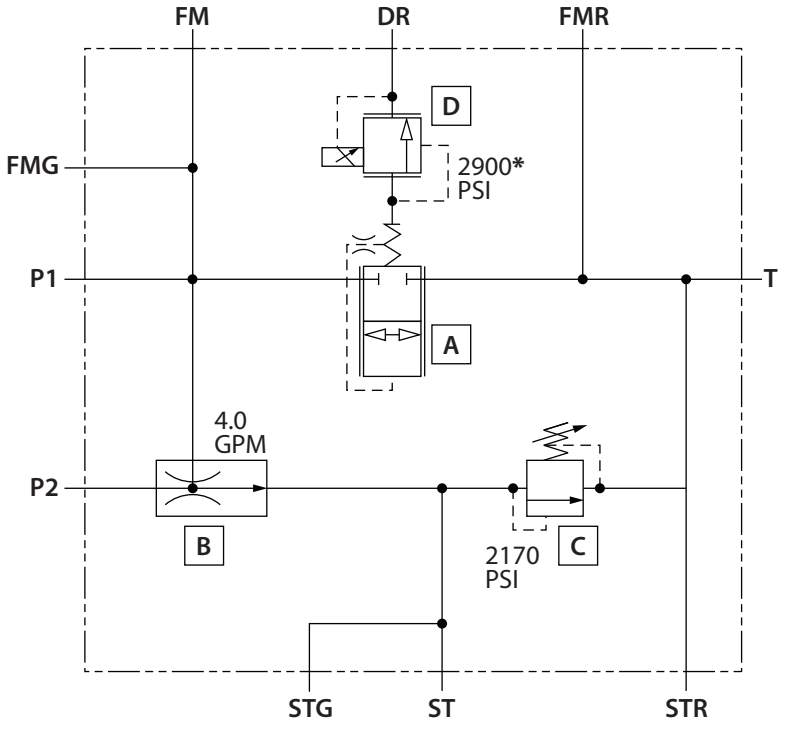
Oil flow returning form the steering circuit and the fan/oil cooler circuit will merge together in the manifold and flow out of the return port (T) through a 10 micron nominal hydraulic oil filter and back to the reservoir.



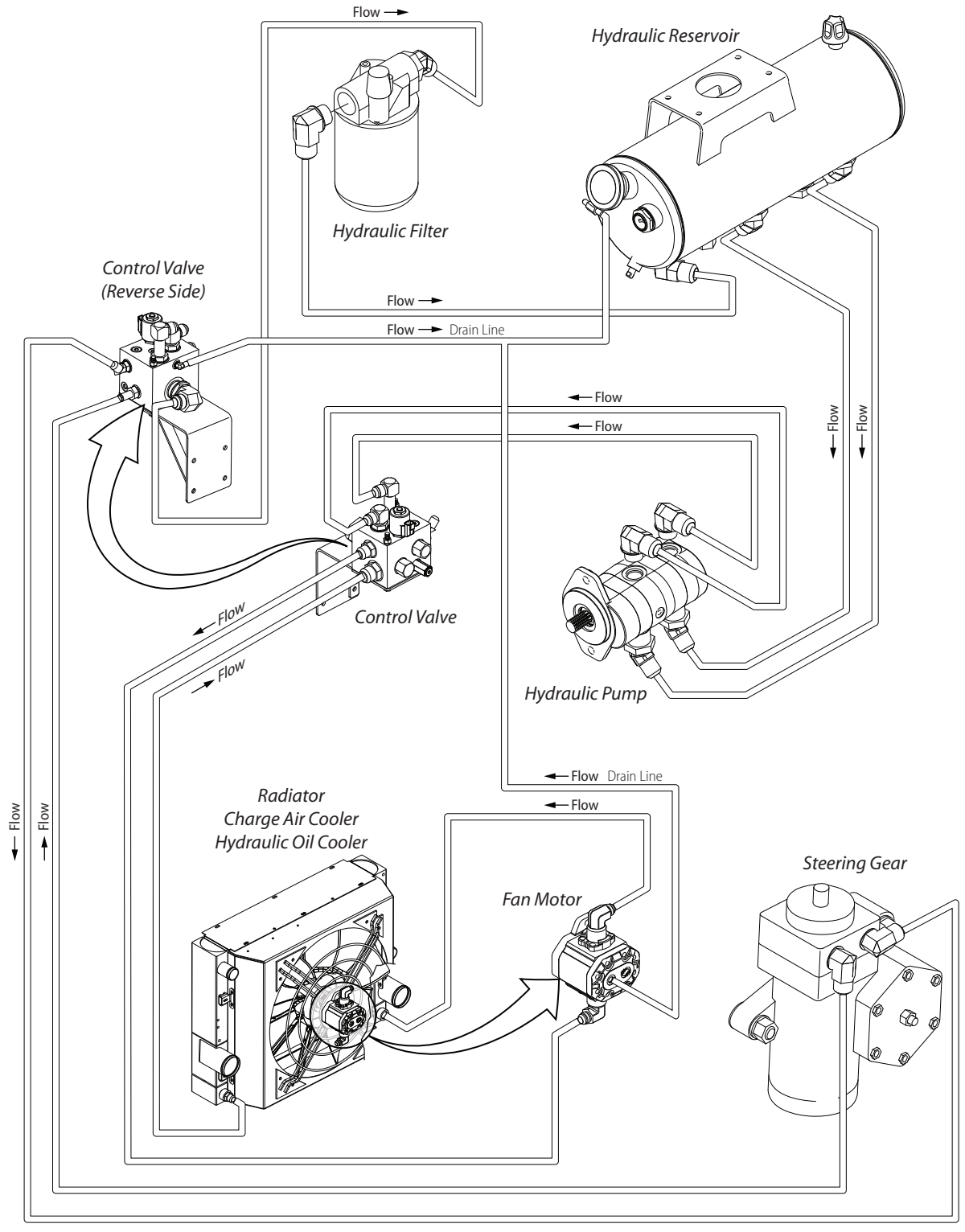
Control Valve
(Reverse Side)

Control Valve





* 2900 PSI - Cummins ISC
2610 PSI - Cummins ISB &



Hydraulic Fan Drive, A3RE

Intake Overview

Clean air is necessary for efficient fuel combustion and for normal engine life. If allowed to enter the engine, airborne contaminants combine with engine oil to form an abrasive compound which may drastically shorten engine life.

On All American Forward Engine, the fresh air intake is located behind the right access panel on the front of the bus. Air enters through a screened duct into the air filter, mounted to the right of the radiator, and accessible from underneath the front bumper.

On All American Rear Engine, the fresh air intake grille is located at the top rear of the right side of the bus, immediately rearward of the rearmost window. Air enters through leuvers in the body panel into a screened duct leading to the air cleaner, which is mounted in the top right of the engine compartment. An optional precleaner (Feature 40170-01) is installed on some All American Rear Engines, immediately behind fresh air intake grille.

Fresh air passes through ductwork leading to the air filter, where airborne dirt, dust and other foreign particles are trapped in the replaceable dry filter element.

Air from the air filter enters a duct leading to the intake side of the engine's turbocharger. The turbocharger contains two turbine chambers which are internally sealed from each other. Exhaust gas passes through the exhaust-side chamber, driving the turbine vanes and shaft at high RPM before passing into the exhaust system. The turbine shaft passes through the body of the tubo charger to the intake chamber, where it drives the compressor vanes, drawing intake air from the air filter, and compressing into the inlet tube of the Charge Air Cooler.

Compressing the air causes it to give off heat. The purpose of the Charge Air System is to remove this heat before the compressed air enters the engine intake manifold. The Charge Air Cooler is a radiator-like component mounted directly to the front of the engine coolant radiator. Although the two radiators are mounted as a unit, they are components of two separate circuits and do not share air or coolant. Ambient air is drawn by the radiator fan through the cooling fins of both coolers. The cooled intake air proceeds from the CAC to the intake manifold, where it enters the engine combustion chambers under compression. This increases engine performance, and reduces emissions due to more efficent burning of the diesel fuel. The Charge Air Cooler is illustrated in the Cooling System chapter.

Air Restriction Indicator, Forward Engine

Air Restriction Indicator

A restriction indicator is mounted in the intake tract between the air filter and the turbo. The restriction indicator is designed to provide a visual warning in the event of overly restricted air intake, as in the case of a clogged air filter element or the presence of debris. The restriction indicator may be fitted with an option to drive a dash-mounted air restriction gauge.

On All American Forward Engine, the air restriction indicator is visible inside the right front access panel, next to the fresh air inlet. On Rear Engine All Americans, the air restriction indicator is visible in the engine compartment, mounted on the side of the duct leading from the air filter housing.

Air Restriction Indicator, Rear Engine

At a vaccuum of 25 inches H_2O, the red piston locks, indicating that the air intake tract is too restricted.

During engine operation, the indicator monitors vaccuum pressure immediately downstream of the air filter. As vaccuum increases, the indicator's red piston becomes visible through the clear portion of the housing indicating that air flow is being restricted by a clogged filter, debris, or other obstruction. The Air Restriction Indicator is variable until the monitored vaccuum increases to a measure of 25 inches H_2O. At that measure, the red piston fills the clear portion, and locks in its position. The indicator must then be manually reset by pressing the reset button after the restrictive condition has been corrected.

CAUTION ***The Air Restriction Indicator activates only when an air flow restriction has occured. A normal reading (no red showing) must not be misunderstood as an indication that the air filter is clean, and does not preclude the need for other inspection and maintenance. For example, a leak in the intake will allow damaging debris to enter, but will not be indicated by the Air Restriction Indicator.***

Filter restriction and proper operation of the indicator may be verified by pressing the reset button on the bottom of the indicator. If restriction is occurring, the red indictor will move when the engine is under load. The indicator will lock in position if the monitored vaccuum increases to 25 inches H_2O.

It is important to understand that the Air Restriction Indicator does not detect leaks, and will not properly indicate restrictions in a leaking system. Check for leaks in all inlet hoses, tubes and connections. If a leak is found, correct it immediately, using original replacement parts and torqing all clamps.

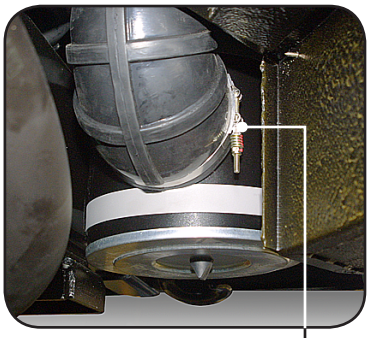
The Air Restriction Indicator can also be tested using a calibrated vacuum gauge and vacuum pump. Check the full range of the indicator, and verify that the red indicator locks into position at 25 inches H_2O. The Air Restriction Indicator is not repairable, and should be replaced if found to be operating incorrectly.

Intake System Maintenance

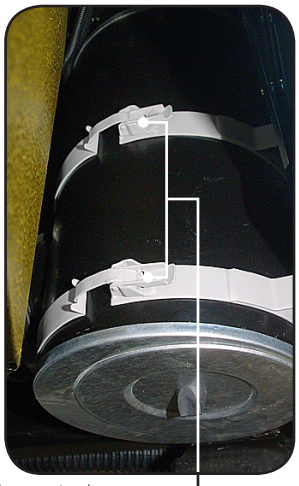
Although it is a simple system, dilligent maintenance and inspection of the air intake tract is critical. Never run the engine with the air cleaner or its filter element removed. Use only original replacement parts to avoid poor fit and consequent air leakage.

See the Specifications and Scheduled Maintenance chapter for recommended intake system inspection intervals.

CAUTION ***The intake system inspection and maintenance intervals indicated in this manual are guidelines which assume normal operating conditions. Appropriate service intervals vary according to operating conditions. In dusty or high humidity environments, more frequent service is required.***



A3FE Air Filter elbow clamp



A3FE Air Filter mounting clamps

General Inspection

Under normal operating conditions, inspect the Air Restriction Indicator daily (more frequently in dusty high humidity conditions). Inspect the air intake system every 3 months or 5000 miles. Inspect the system for:

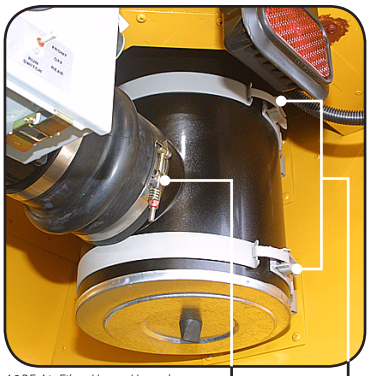
- Air Restriction Indicator. If red indicator is visible, replace the air cleaner element, and check the system for debris and other restrictions.
- Clamps. Tighten loose clamps and check for proper fit and seal. Replace if corroded, broken or otherwise damaged.
- Ducts and piping. Inspect for wear, damage, or abrasion.
- Air cleaner element. Replace if soiled, wet, torn, or otherwise damaged. Ensure proper installation and seal.
- Mounting brackets. Check for loose or damaged mounts.
- Charged air system piping. Tighten loose clamps. Check for wear spots and holes in the piping.
- Air compressor inlet lines. Tighten. Check for wear or other damage.

Clamps should be tightened to the following specifications:

Spring-loaded clamps. ***Tighten to near full spring compression.***
T-Bolt clamps. ***Tighten to 50 in. lbs. (5.6 Nm).***
Worm gear clamps. ***Tighten to 38–42 in. lbs. (4.2–4.7 Nm).***
Hose clamps already in service. ***Tighten to 10 in. lbs. (1.1 Nm).***

Air Filter Replacement

Replace the air filter element at least once a year, and whenever the Air Restriction Indicator has been activated (shows red). Other indicators of a dirty air cleaner element include loss of power or excessive exhaust smoke. To replace the air cleaner element:



1. Loosen the spring clamp which secures the intake elbow (FE) or intake hump hose (RE) to the air filter canister. Push the intake elbow or hump off of the filter flange.

2. Release the clasps of the two mounting clamps and remove the filter.

3. On Rear Engine All-American, remove the clamp and intake tube from the top of the filter. Clean the tube and install it on the new filter.

4. Before replacing the element, inspect all clamps, hoses, piping and seals:

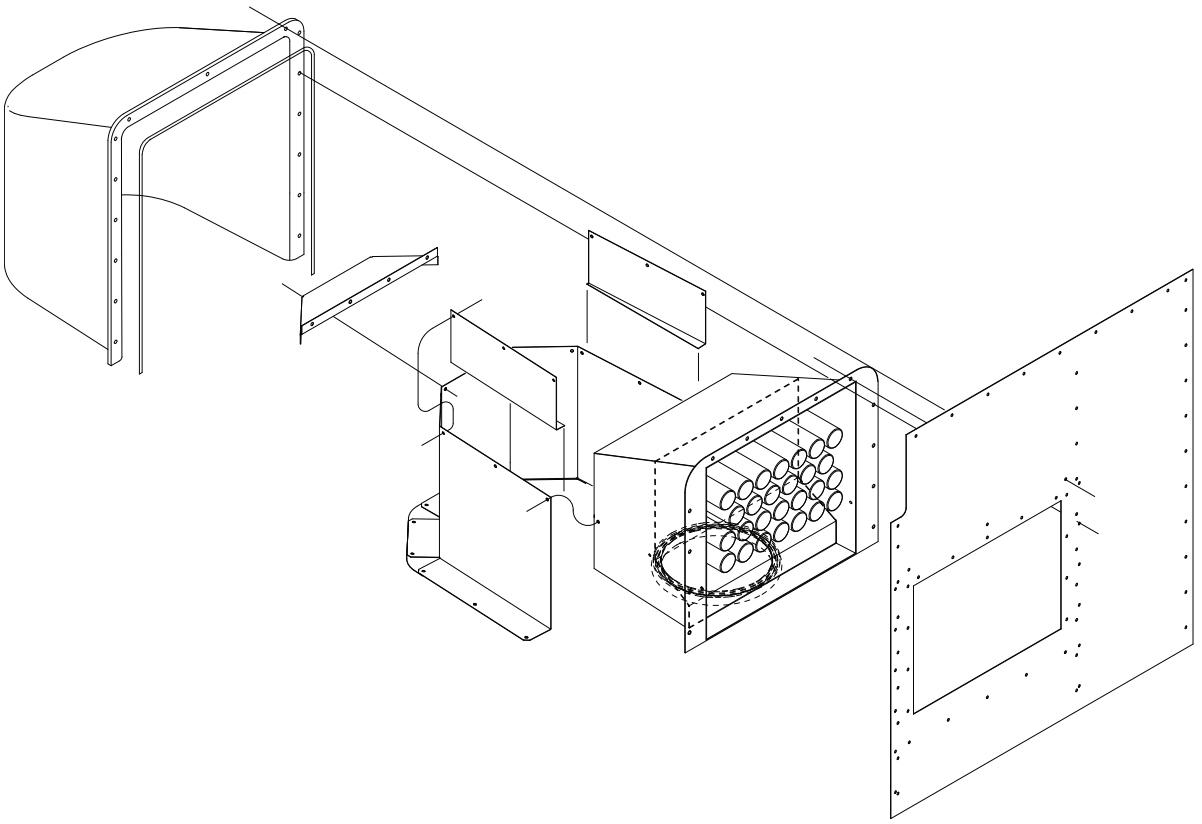
   - Inspect inside the intake elbow or hump hose for signs of dust or debris finding its way into the system through leaks. Replace any damaged components allowing the leak, and clean the debris inside the elbow and ducts before installing a new element.

   - If evidence of leaks is found, check the tube between the charged air cooler and the engine intake for contamination. If contamination is found, the charged air cooler should be replaced.

5. Install a new air cleaner element, fully seating its top seal.

6. Assemble removed parts in reverse order of disassembly. Ensure that the intake elbow or hump hose is properly seated all the way around the flange of the filter. All duct connections downstream of the air filter must be air tight.

7 Reset the Air Restriction Indicator by pushing the reset button. This will allow the indicator to monitor the newly installed components.



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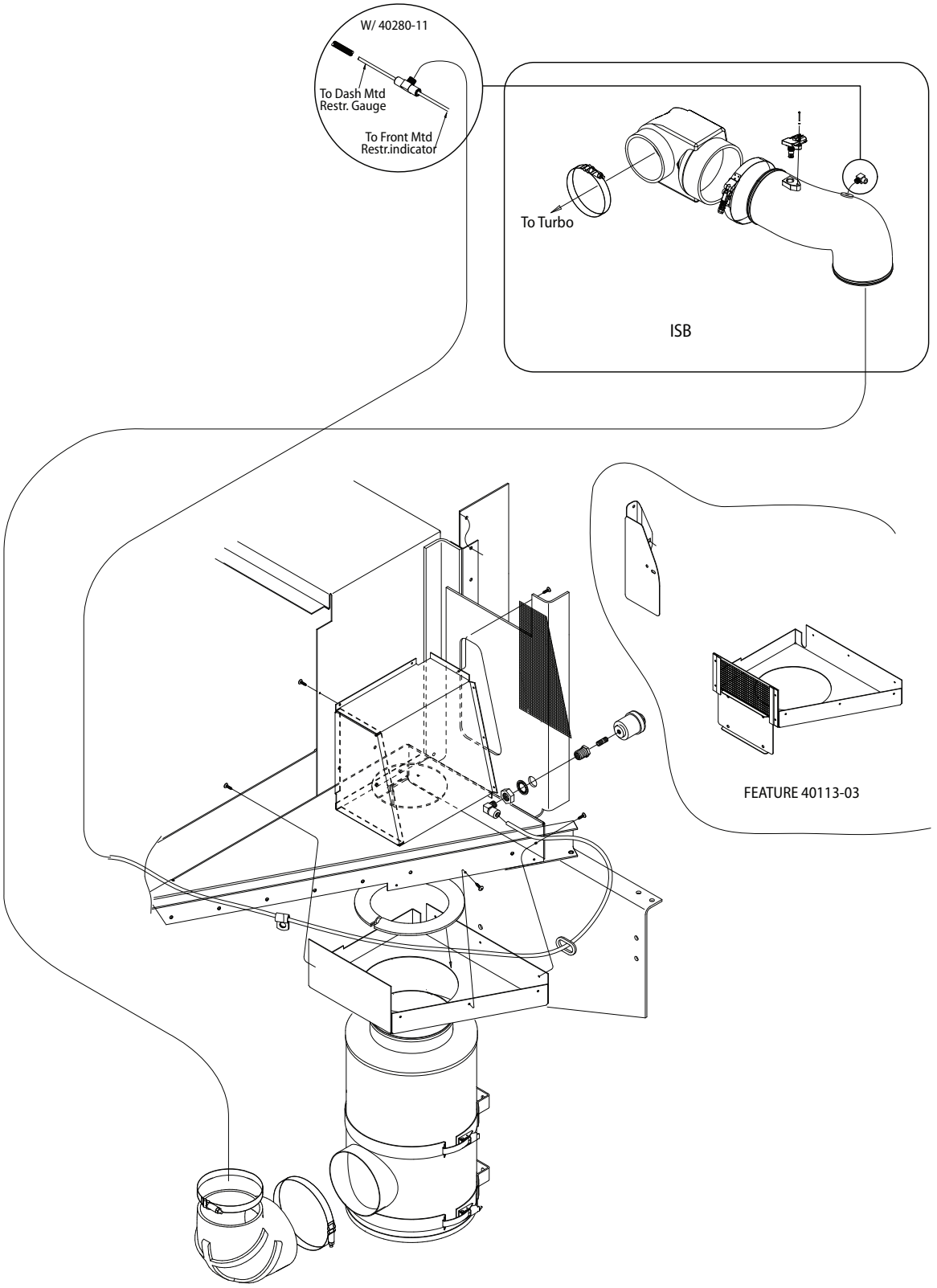
Intake Tract: A3RE Precleaner



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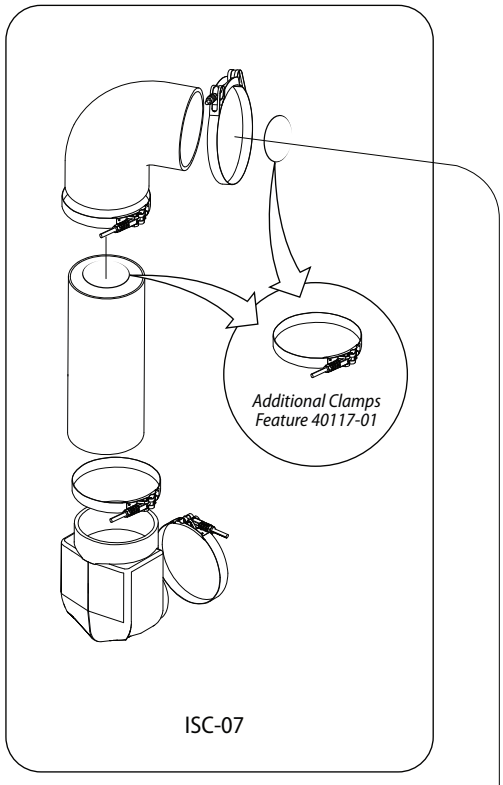
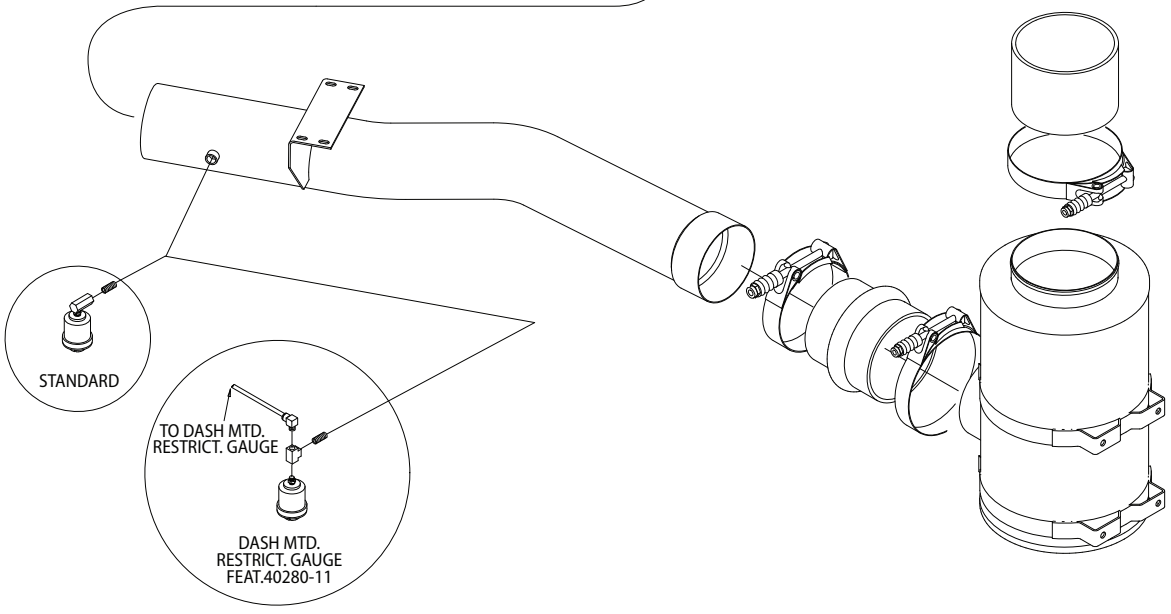
Intake Tract: A3FE With ISB





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Intake Tract: A3RE With ISC

About 2010 Exhaust Emissions

In 2010, emissions requirements changed for all on-road vehicles equipped with a diesel engine. Both Nitrogen Oxide (NOx) and particulate matter are reduced by 90% from 2002 levels. Specifically, NOx was reduced to 0.2-g/hp-hr while the particulate standard was reduced to 0.01-g/hp-hr. The Environmental Protection Agency (EPA) allowed for NOx phase-in from 2007 through 2009. During this time 50% of the engines produced met the 0.2-g/hp-hr NOx standard, while 50% continued to meet the 2.5-g/hp-hr NOx+NMHC standard. Most engine manufacturers used the NOx phase-in provisions along with averaging to certify engines to a NOx value roughly halfway between 2.5-g/hp-hr NOx+NMHC and the 0.2-g/hp-hr NOx levels through 2009. This calculates to approximately 1.2-g/hp-hr NOx. Beginning in the 2010 emission compliant engines, 100% of the 0.2-g/hp-hr standard for NOx must be met.

The PM level was not phased in, and thus all engine produced were required to be at 0.01-g particulate matter beginning January 2007. In addition to the lower NOx and particulate matter levels, crankcase gases are also included in the emissions measurements. This requirement has driven closed crankcase systems in 2007 or ultra-low emissions from open systems. In open systems crankcase gases are vented into the atmosphere through a breather/filter tube arrangement. Closed systems reroute crankcase ventilation gases from the breather tube back into the engine intake airflow to be used for combustion.

On-Board Diagnostics (OBD)

Beginning in 2010, the California Air Resources Board (CARB) requires engine manufacturers to phase in On-Board Diagnostics (OBD) on their highest-volume heavy-duty engines. By 2013 all engines including the ISB and ISC produced will have to be OBD-compliant per CARB requirements. It is expected that the EPA will have the same OBD requirements as CARB beginning in 2013. The CARB is also requiring engine manufacturers to comply with a new Service Information Regulation (SIR). In essence, the SIR requires that engine manufacturers provide the necessary troubleshooting, maintenance and service information to third-party service centers as well as to their own service channel. This approach should allow customers to have access to proper diagnosis and repair of their engine to ensure that the engine remains in emissions compliance for the life of the engine.

The OBD system detects emissions-related malfunctions, alerts the operator of the bus to the detected malfunction, stores diagnostic records of the malfunction and supports off-board communications to a diagnostic service tool (e.g., scan tool) to allow the efficient service and maintenance of your bus. The Service Information Report makes it possible for the aftermarket service centers as well as the engine manufacturer's support centers to service and maintain the emissions control systems to their proper performance levels.

Fuel and Lubricating Oil Requirements

The EPA has lowered the limit for sulfur in diesel fuel from 500 parts per million (ppm) to 15 ppm. This fuel standard was phased in beginning October 1, 2006 (80% participation) through September 1, 2010 (100% participation). In 2010, all indications show that 15-ppm Ultra-Low Sulfur Diesel (ULSD) fuel is widely available. Use of ULSD fuel is critical for proper performance of exhaust aftertreatment systems. Beginning in 2007, all heavy-duty, mid-range and light-duty diesel engines are required to operate using ULSD fuel.

Biodiesel is growing in popularity which is why Cummins Engines are capable to operate on B20 biodiesel. Refer to the Cummins service literature or service center for more information.

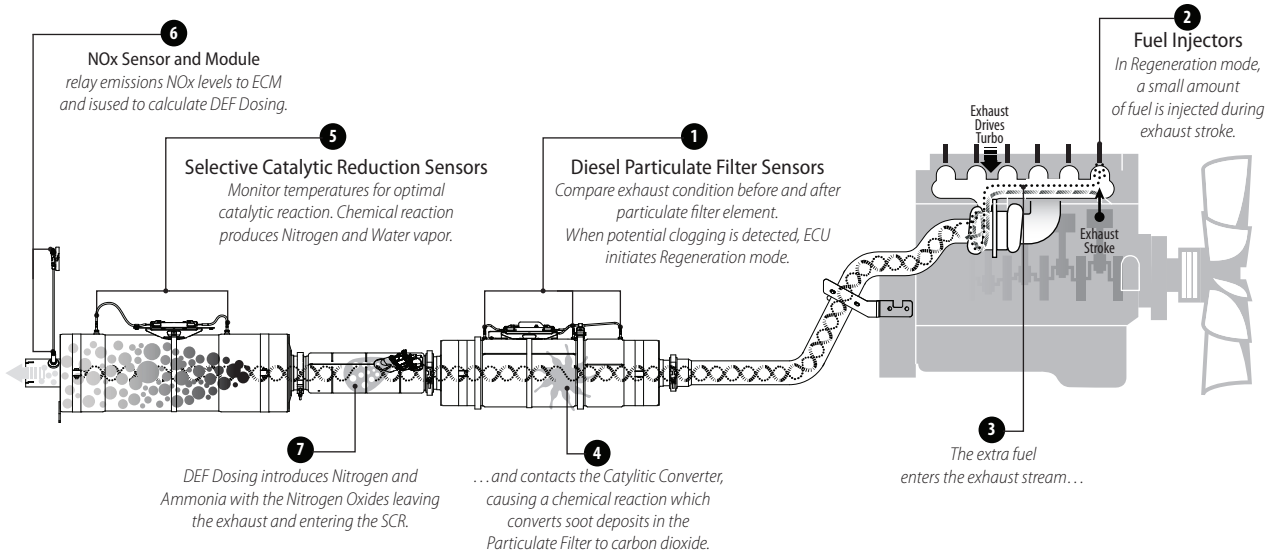
New specifications have been released for lubrication oil compatible with low-emissions engines for 2007-2010. The primary focus has been to make the oils compatible with exhaust aftertreatment devices (e.g., diesel particulate filter). In 2007 the requirement had been to reduce ash in the oil in order to enable extended maintenance intervals on the diesel particulate filter while maintaining the important lubricity capability of the lubricant. The low-ash oil classification (CJ-4) that was released for 2007 on-highway emission compliant engines must also be used in the 2010 emission compliant engines. A new oil classification is not required for 2010.

Integrated Cooled EGR

Cooled Exhaust Gas Recirculation (EGR) technology, introduced in 2002 to meet the 2.5-g/hp-hr NOx+NMHC standards, created the foundation for the EPA 2007 and EPA 2010 products. Cooled EGR is very effective at reducing NOx levels. The EGR system takes a measured quantity of exhaust gas, passes it through a cooler before mixing it with the incoming air charge to the cylinder. The EGR adds heat capacity and reduces oxygen concentration in the combustion chamber by diluting the incoming ambient air with cool exhaust gases. During combustion, EGR has the effect of reducing flame temperatures which, in turn, reduces NOx production since NOx is proportional to temperature. This allows the engine to be tuned for the best fuel economy and performance at lower NOx levels. EGR was used to attain the NOx levels introduced in 2007 and in current 2010 engines. In order to control both NOx and particulate emissions accurately, the amount of recirculated exhaust gas and air has to be precisely metered into the engine under all operating conditions.

This has driven the use of advanced Variable Geometry Turbochargers (VGT) that continuously vary the quantity of air delivered to the engine. The VGT features a one-piece sliding nozzle which moves continuously to vary the power of the turbine and the amount of air delivered to the engine. It is used in concert with an EGR control valve to accurately meter the EGR into the intake system

Cummins Regeneration



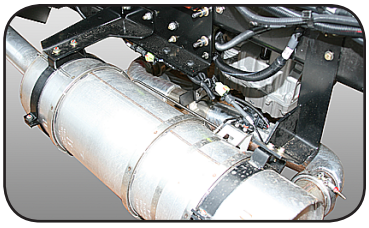
Exhaust System

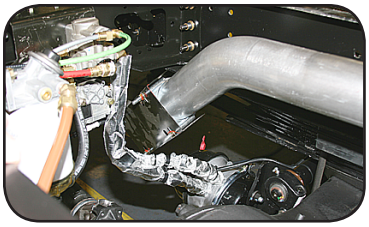
New federally mandated emission standards affect all buses equipped with 2010 emission standard engines. The exhaust systems for Cummins engines in Blue Bird buses are aftertreatment systems which incorporate a Diesel Particulate Filters (DPF), a Decomposition Reactor and a Selective Catalytic Reduction (SCR) system instead of ordinary mufflers. This sophisticated exhaust system reduces emissions by trapping particulate matter (soot) and reducing the level of NOx (nitrogen oxides) in the exhaust stream.

As the exhaust leaves the turbo on the engine it is first channeled through the DPF. The DPF contains a filter which traps the particulate matter in the exhaust stream. The rate at which the soot accumulates is dependent upon multiple conditions including the quality of the diesel fuel, type of engine oil, ambient temperature, engine load, and other factors. Over time, the trapped particulate matter accumulates in the DPF filter and must be removed through a process referred to as regeneration. Regeneration uses heat to convert most of the trapped particulate matter in the filter into carbon dioxide, and leaves behind a small amount of ash. Regeneration is conceptually similar to the cleaning mode of a self-cleaning oven in that heat removes the accumulated soot.

CAUTION ***In 2010 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications. In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.***

As the exhaust leaves the DPF it enters a decomposition reactor where a fine mist of Diesel Exhaust Fluid (DEF) is sprayed into the exhaust stream. The DEF vaporizes in the decomposition reactor converting it into Carbon Dioxide and Ammonia. This exhaust mixture then leaves the decomposition reactor and enters the SCR catalyst which prompts a chemical reaction. The harmful NOx in the exhaust combines with the ammonia (NH_3) to form harmless nitrogen (N_2) and Water Vapor (H_2O). Because of the higher operating temperatures involved, the exhaust system components are insulated from other chassis components.





The exhaust systems of 2007 and newer engines incorporate engine-specific Diesel Particulate Filters, which operate at higher temperatures during their Regeneration cycles. The front exhaust pipes are insulated, and heat shields are installed at locations along the exhaust tubing.

Engine-Specific Technologies

Although the purpose and general principles of aftertreatment exhaust systems are similar among engine manufacturers, both the terminology and the mechanisms to perform "active" regeneration differ. Cummins has developed unique technologies for accomplishing and controlling the active regeneration process. The engine-specific ECMs which control the process are also different. Engine manufacturers differ in the construction of the DPF units, the exhaust flow paths, and other related components. It is for these reasons that the service technician must now regard that portion of the exhaust system from the engine to the outlet port of the SCR system as part of the engine package itself.

This chapter provides conceptual explanations of the Cummins systems. However, the service technician must refer to the engine manufacturer's operators' manual and service literature regarding service and maintenance of the 2010 exhaust system.

Exhaust Aftertreatment

2010 emissions standards-compliant Cummins engines incorporate an Aftertreatment System. The first part of the aftertreatment system is to trap particulate matter (soot) in the DPF filter. As the soot accumulates on the filter it must be cleaned to prevent backpressure. Cleaning is accomplished with heat created through regeneration. Regeneration occurs in three ways:

- Some regeneration occurs "naturally" whenever operating conditions (speed, engine load, etc.) result in exhaust system temperatures high enough to oxidize accumulated soot. Terminology differs between engine manufacturers, but this unassisted regeneration mode can generically be referred to as "passive" regeneration.
- Regeneration can be caused by raising the temperature of the exhaust system. A set of sensors mounted on the DPF assembly enable the Electronic Control Module (ECM) to monitor the buildup. The ECM then automatically activates and de-activates a system designed to increase exhaust temperature when the ECM senses that regeneration is needed, and when certain requirements, including a minimum travel speed, are met. This automatic "heat assisted" mode can be generically referred to as "active" regeneration.
- Regeneration can be manually activated by means of a switch. This procedure is generically referred to as "stationary" or "manual" regeneration, and should only be performed by or under the direction of a qualified service technician, and in a controlled environment to avoid the potential for human injury or fire hazards.

The ECM communicates the need for regeneration to the driver by a set of visual and audible signals in the instrument cluster. An additional alert, the High Exhaust System Temperature (HEST) indicator, notifies the driver whenever exhaust system temperature is high due to recent regeneration. Periodically, the normal ash accumulation which results from the regeneration process must be removed from the DPF using equipment designed for that purpose at qualified engine service facilities. Refer to the engine manufacturer's documentation for these service intervals.

Cummins Passive Regeneration

When driving at high speeds or with heavy loads, the exhaust system is hot enough to turn soot accumulation inside the DPF into carbon dioxide. Temperatures generated in this mode are comparable to those of pre-2007-standards engines.

At moderate and continuous speeds or engine load conditions, normal exhaust temperatures may be maintained at a high enough level for normal operation to prevent additional accumulation. At moderate-to-heavy operating conditions, normal exhaust heat may be high enough to reduce accumulated soot levels.

Cummins Active Regeneration

Accumulation occurs most at low speeds and relatively low temperatures. Frequent stop-and-go and continual low-speed operation typical of some school bus routes may not always generate sufficient heat to keep the particulate filter clear.

Sensors monitor the pressure differential before and after the DPF, and also monitor temperature. The pressure and temperature data is communicated to the ECM. When the pressure / temperature readings indicate that the particulate filter is beginning to become restricted, the ECM may signal the system to enter an Active Regeneration mode.

During Active Regeneration, a small amount of fuel is injected into the exhaust stream by the engine's fuel injector during the engine's exhaust stroke. This fuel reacts with the diesel oxidation catalyst in the DPF, raising the temperature of the exhaust flow sufficiently to remove the accumulation. This process activates and deactivates automatically as-needed during normal operation.

Active Regeneration begins only if DPF accumulation has reached a certain level and if the bus is moving above a preset speed threshold (approximately 40 mph). If the bus is operated above the speed threshold long enough, the soot accumulation on the filter clears and Active Regeneration mode stops automatically.

If the bus is slowed to below a certain speed threshold while in Active Regeneration mode, the Active Regeneration stops, even if the cleaning process has not completed. If the bus slows or stops while the exhaust system temperature is still high due to recent Active Regeneration, the High Exhaust System Temperature (HEST) indicator appears on the driver's instrument panel to notify the driver that the exhaust system temperature is elevated.

Cummins Stationary Regeneration

Active Regeneration removes the accumulation at an increased rate. However, each time the bus slows to below the speed threshold, and each time exhaust temperature drops to levels insufficient for soot to be cleared, accumulation may increase.

Depending upon the operating conditions, there may not be sufficient opportunity or duration for either Passive Regeneration (normal running) or Active Regeneration (ECM initiated) to keep the filter clear therefore a Stationary Regeneration must eventually be performed. Stationary Regeneration is initiated with the use of a manually activated switch

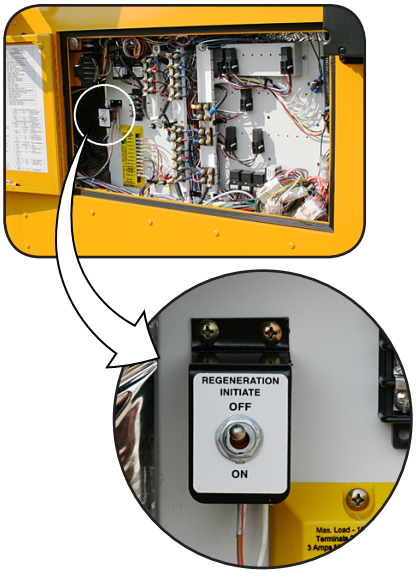
During Stationary Regeneration, temperatures inside the exhaust can exceed 1300°F. Stationary Regeneration must be performed in a controlled environment where precautions are taken to avoid any hazard that might result from the elevated temperatures. Blue Bird strongly recommends that Stationary Regeneration be performed only by, or under the supervision of a qualified service technician. Read carefully the section titled **Stationary Regeneration Precautions**.

Stationary Regeneration is initiated by means of a momentary toggle switch. Operating the switch starts a Stationary Regeneration only if certain conditions are met: The ECM must have indicated that Regeneration is needed (as indicated by the appearance of the DPF indicator). The bus must be stopped with the parking brake on, the engine must be running and the transmission must be in Neutral. During a Stationary Regeneration procedure, the process is monitored and controlled by the engine ECM. Depending on the severity of the restriction, the engine may raise its idle speed. The Regeneration process continues until the filter is clean, and then the process stops automatically. The bus may then be returned to normal service. (For more information, see **DPF Regeneration**.)

Cummins Exhaust Gas Recirculation

In the Cummins ISB engine, a portion of the exhaust is returned to the engine intake which adds an inert gas and reduces emissions. A device on the engine exhaust routes a small amount of the exhaust through a cooler, mixes it with fresh air, and re-introduces it into the intake stream. This helps lower the temperature during combustion, which reduces the formation of Nitrogen Oxides (NOx).

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people. Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on. Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.***



Regeneration switch for use by Service Technicians performing Stationary Regeneration only in a controlled, fire-hazard-free environment.

DPF Regeneration

As with most new mechanical processes, the introduction of more sophisticated exhaust systems in 2007 and 2010 emission standard-compliant engines, a higher degree of understanding is required to troubleshoot these systems. Engine manufacturers have designed their own methods to meet the EPA standards, and therefore describe the process in somewhat differing terms. The Cummins equipped Blue Bird bus system is not complicated, but both Drivers and service technicians should be familiar with the regeneration process.

As soot builds up in the DPF filter, the driver is notified in several stages by visual and audible alerts. As the need for regeneration becomes more severe, the alerts become increasingly imperative to act upon; and the penalty for postponing the needed regeneration also increases.

When the earliest alerts occur, there is ample time to complete a route and then have a Stationary Regeneration procedure performed at a proper facility. If early alerts are ignored, and the condition is allowed to worsen, the engine will eventually de-rate automatically, and performance will reduce noticeably. If the condition is allowed to become severe, a Stationary Regeneration may not be possible, and the DPF may require removal and cleaning with specialized equipment. Therefore, to minimize disruption of your bus operation, the regeneration-related alerts should be heeded and responded to at their early stages as a matter of routine.

Aftertreatment Terms

The following summarizes some of the terms associated with the exhaust systems of Blue Bird buses equipped with 2010 emission standards compliant engines. Both the driver and technician should become familiar with the following terms:

Aftertreatment. The process of filtering engine exhaust in order to reduce emissions, and purging the exhaust system of accumulated exhaust residue.

DPF (Diesel Particulate Filter). A component in the exhaust system which takes the place of a traditional muffler. A DPF contains a special dissimilar metals filter which traps particulate matter (soot), which is then converted to carbon dioxide by the aftertreatment process. The Cummins DPF also contains a DOC also known as a catalytic converter.

Regeneration. The process of cleaning accumulated soot from the filtering components inside the DPF. Regeneration occurs at high exhaust system temperatures to turn the soot into carbon dioxide gas. Regeneration can be thought of as conceptually similar to the clean cycle of a self-cleaning oven.

WARNING ***Postponing regeneration beyond the early indications may result in the engine being automatically de-rated, and reduction of power while driving.***

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people. Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on. Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.***

HEST Indicator (High Exhaust System Temperature). An instrument panel indicator which appears when the exhaust temperature is unusually high due to recent regeneration. This is a normal behavior of the aftertreatment system, intended to notify the driver and technician that the exhaust system temperature is high and that caution should be observed around the exhaust system.

DPF Indicator. An instrument panel indicator which displays when particulate accumulation has reached a preset level in the DPF, and regeneration is needed. The bus should either be operated with a more demanding duty cycle until the indicator goes off, or it should be scheduled for a Stationary Regeneration at a service facility.

DPF Regeneration Levels of Notification

Regeneration—the process which clears soot accumulation in the DPF—occurs automatically as the bus is operated, as long as certain operating conditions (such as minimum speed thresholds) are met. When bus operating conditions do not provide adequate opportunity for the regeneration system to keep the DPF clear, soot begins to accumulate. A system of driver alerts keeps the driver informed of when the exhaust system is in need of regeneration, and of high exhaust temperature associated with regeneration. Several levels of regeneration alerts occur in sequence, each indicating a more imperative warning.

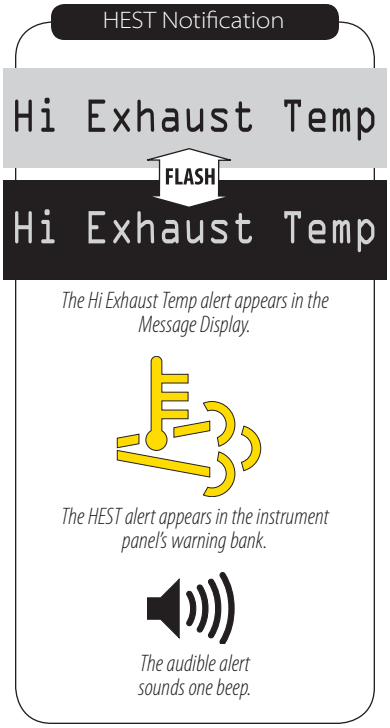
High Exhaust Temperature Notification

The High Exhaust System Temperature (HEST) indicator appears to alert the driver when exhaust temperature is unusually high and that prudent judgement should be applied regarding the proximity of people or combustibles to the exhaust system. For example, the bus should not be parked on a surface of grass or weeds.

The HEST indicator appears whenever the exhaust temperature is high (752°F or above), regardless of moving speed.

The driver should be familiar with and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when the HEST indicator is on.

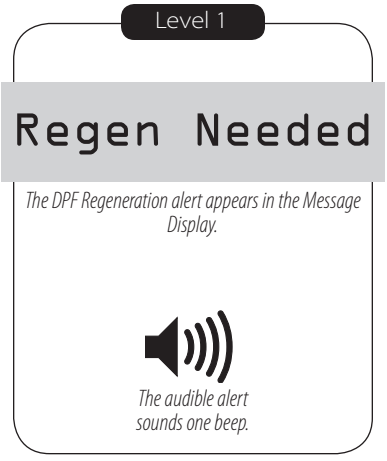
- The HEST alert appears in the instrument panel's warning bank.
- The audible alarm sounds one beep.



Level 1 Regeneration Notification: DPF Indicator Appears

In low-demand operating conditions, it is possible that the regeneration system does not have sufficient opportunity to prevent particulate build-up in the DPF. The ECM senses that accumulation is occurring and that regeneration is needed. When notified, Regeneration should be done as soon as possible. The driver is notified as follows:

- The DPF Regeneration alert activates.
- The audible alert sounds one beep.



The regeneration can be accomplished in either of two ways: If practical, the bus could simply be operated for a while at a speed above the automatic regeneration threshold; or the bus could be taken to a suitable location to have a Stationary Regeneration procedure performed.

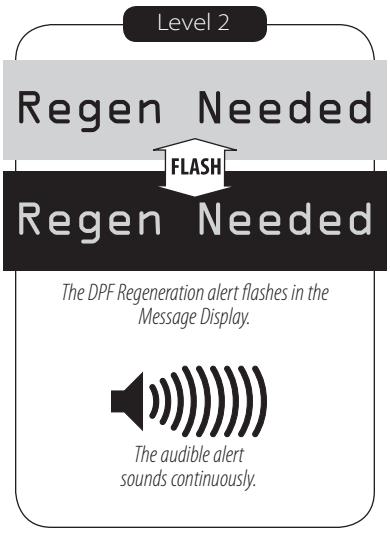
If the bus is operated at a minimum highway driving speed (40 mph Cummins), the automatic regeneration system will activate. If minimum speed is maintained long enough (usually 20-30 minutes), the automatic regeneration mode can likely reduce the soot sufficiently to cause the DPF Icon to go off.

Therefore, the first appearance of the DPF icon should be perceived by the driver as a normal notification of action that needs to be taken, but not as an emergency situation. Typically, even if the bus route does not afford immediate opportunity for higher-speed operation, there is sufficient time to finish the bus route and return to the bus maintenance shop before a higher level of notification occurs. Exactly how much time after the first appearance of the DPF indicator represents is dependant upon specific operating conditions. However, current data from Cummins suggest that, at this level of notification, the DPF needs to undergo regeneration within two to six hours of bus operation. If regeneration does not begin, the next level of notification will activate.

Level 2 Notification: DPF Indicator Blinks

If the bus continues to be operated without taking the measures indicated by a Level 1 Notification (described above), particulate accumulation continues, and a Level 2 notification occurs:

- The DPF Regeneration alert begins to flash.
- The audible alarm sounds continuously.
- The engine may be automatically de-rated.



The above indications should be viewed with a higher degree of urgency and that the exhaust system is in need of regeneration soon. As soon as practical, the bus should be operated at or above the minimum speed needed to allow automatic regeneration to activate, or a Stationary Regeneration must be performed. Current data from Cummins suggest that at this level of notification, regeneration needs to be performed within the next one to two hours of bus operation. Otherwise, the third level of notification will occur.

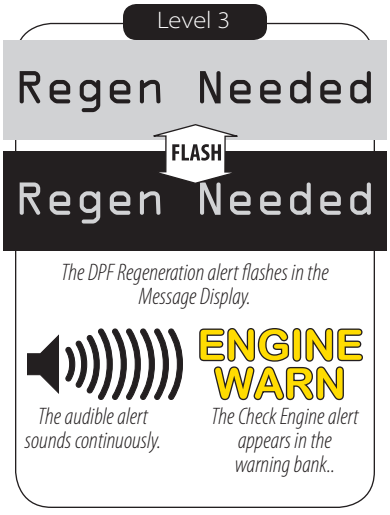
Level 3 Notification: Check Engine Indicator Appears

If the bus continues to be operated without taking the measures indicated by a Level 2 Notification, particulate accumulation will continue. These indicators are activated:

- The DPF Regeneration alert continues to flash.
- The audible alert sounds continuously.
- The engine is automatically de-rated.
- The Check Engine alert appears.

The above indicates that a Manual Regeneration must be performed as soon as possible. Because the engine is automatically de-rated it may not be possible to drive at sufficient speed to cause active regeneration to occur.

Depending upon the severity of the accumulation, the regeneration switch may not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.



Level 4 Notification: Stop Engine Indicator Appears

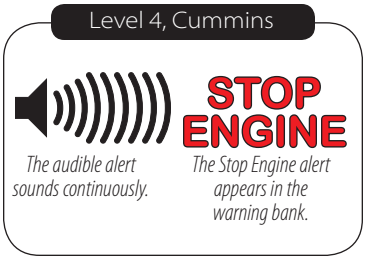
If the bus continues to be operated without taking the measures indicated by a Level 3 Notification, particulate accumulation reaches a critical level. Engine power is automatically de-rated *further* by the ECM. These indicators are activated:

- The DPF Regeneration alert deactivates.
- The audible alert sounds continuously.
- The engine is further de-rated.
- The Check Engine alert deactivates.
- The red Stop Engine alert appears.

The above indicates that accumulation has progressed to critical levels and the bus should be stopped with the engine off as soon as it is safe to do so. The bus should remain shut down until the aftertreatment system has been serviced.

The regeneration switch will not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.

Removal and cleaning of the DPF using specialized equipment may be required.



Stationary Regeneration Precautions

During active regeneration, the exhaust system can reach extremely high temperatures. Automatic active regeneration, which occurs while driving the bus, is programmed to occur only when the bus is moving at a minimum speed, and it stops when the vehicle slows or stops.

The HEST indicator appears whenever high temperature condition exists.

When performing a Stationary Regeneration, the entire process occurs for an extended period while the bus is stopped. It is therefore critical that prudent human safety and fire hazard precautions are followed. Those precautions include:

- Read, understand, and abide by all the precautions pertaining to regeneration procedures in the engine manufacturer's Operator's Manual.

- If at all possible, the Stationary Regeneration procedure should be conducted at a service facility by trained technicians.

- The Driver's first priority is the safety of the passengers. If a Stationary Regeneration must unavoidably be done by the Driver under a qualified technician's direction, alternate transportation should be arranged first, or passengers should be removed under proper supervision to a location away from the bus.

- Select an appropriate location to park the vehicle.

    - Choose a surface that will not burn or melt under high temperature, such as clean concrete or gravel, *not grass or asphalt*.

    - Ensure that nothing that can burn, melt, or explode (gasoline, wood, paper, plastics, fabric, compressed gas containers, hydraulic lines) is near the exhaust outlet. Abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when performing a Stationary Regeneration.

- Park the bus securely.

    - Set the parking brake. Put the transmission in Neutral. Chock the wheels.

- Secure the exhaust area.
    - If bystanders might enter the area, set up barriers to keep people safely away from the exhaust outlet.
    - If the procedure is performed indoors at a service facility, attach an exhaust discharge pipe rated for at least 1500°F.
    - Keep a fire extinguisher nearby.
- Check exhaust system surfaces to confirm that no tools, rags, grease, debris or any other objects are on or near the exhaust system.
- Start the engine.
- Operate the Regeneration Switch to begin the regeneration process.
- Monitor the process. If any unsafe condition occurs, shut off the engine immediately. During the regeneration process, the engine may change speed, and the turbocharger may whistle. When the process is complete, the engine will return to normal idle speed. Exhaust gas and exhaust surface temperatures will remain elevated until they have had time to cool to normal levels.

SCR Treatment

The Selective Catalytic Reduction (SCR) system uses diesel exhaust fluid (DEF) as a chemical reactant. The DEF converts to ammonia in the exhaust stream. The SCR catalyst is mounted in the exhaust stream and is similar in outward appearance to a muffler. It contains chemical compounds which, in the presence of ammonia, help transform nitrogen oxides into harmless nitrogen and water.

In an SCR system, the rate at which DEF is sprayed must be tightly controlled. If the rate is too high, not all of the ammonia will react with the NOx and some ammonia will "slip" through the catalyst. If the rate is too low, the desired NOx reduction will not be achieved. Both situations are undesirable and must be avoided.

The SCR system consumes DEF at a rate of approximately 2% of the amount of fuel used, depending on bus operation. Therefore a 15 gal tank of DEF will treat approximately 750 gallons of diesel fuel.

The DEF tank level indicator can be found in quadrant 3 of the message display center located in the instrument cluster. This display provides a constant reading indicating the percent of fluid in the tank. If a problem is identified with the amount of fluid or the quality of the fluid a priority message will appear in quadrant 1 of the message display center indicating the fault.

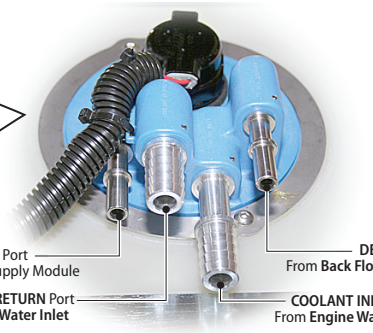
Keeping adequate levels of DEF in the tank is crucial to the operation of the SCR system. When low levels are indicated, refill the tank using only approved DEF solution. The DEF has its own tank and fill port with a blue cap. You will notice the fill port is smaller than the diesel fuel port. This is to prevent putting diesel fuel into the DEF tank. Conversely, care should be given not to put DEF in the diesel fuel tank. Read all decals carefully before refilling.

CAUTION ***DO NOT put diesel fuel in the DEF tank. DO NOT put DEF in the fuel tank of the bus.***

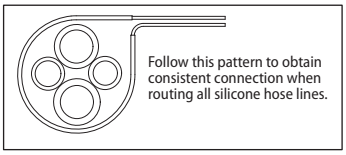
DEF Fill Door

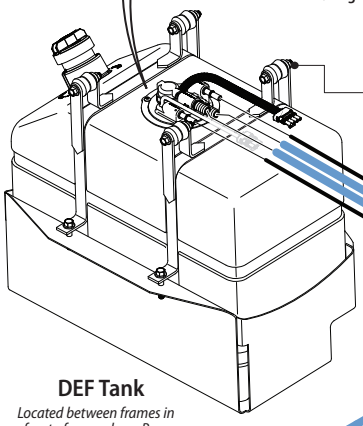
DEF Fill located to the left of the entrance door.

Diesel Fill



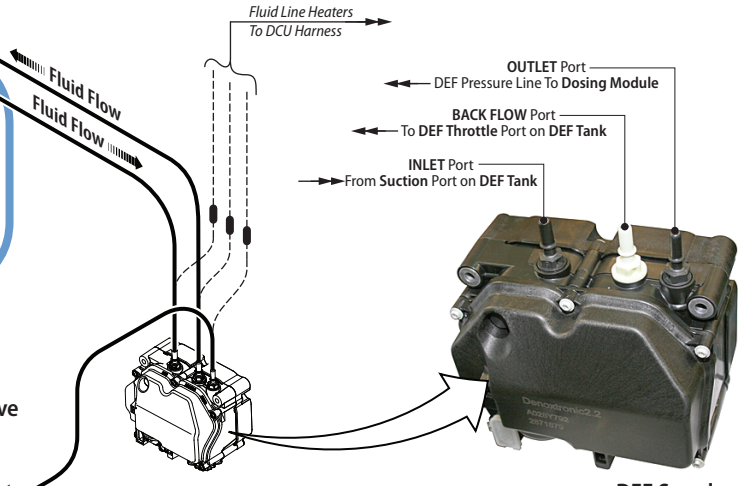
DEF Tank Multifunction Head



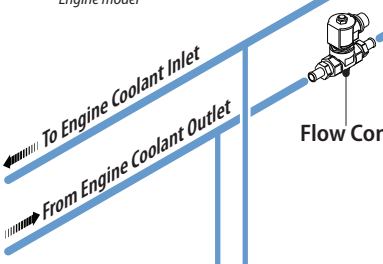


DEF Tank

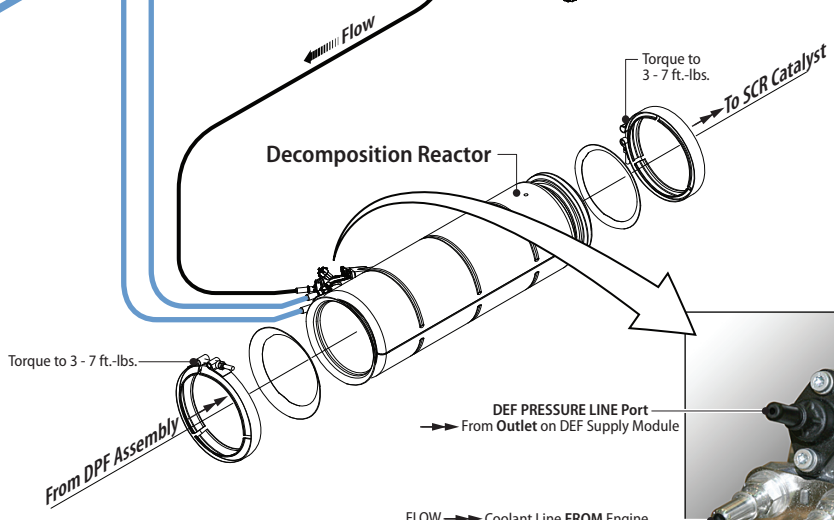
Located between frames in front of rear axle on Rear Engine model

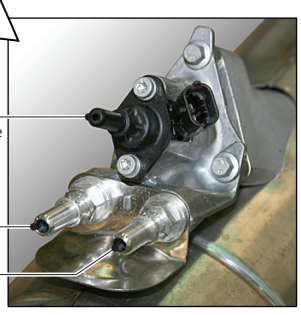


DEF Supply Module



Flow Control Valve





Dosing Module

SCR System Plumbing

Selective Catalytic Reduction Components

Dosing Control Unit (DCU). The DCU is a computer, designed as the central control for the diesel exhaust fluid dosing system. This module handles the dosing activity by energizing and de-energizing the Dosing Module. It also monitors and adjusts the diesel exhaust fluid tank temperature by adjusting the engine coolant control valve. In cold temperatures it will also energize electrical line heaters on the diesel exhaust fluid lines to thaw and prevent freezing during operation. The diesel exhaust fluid tank level sensor information is also monitored by the DCU. The dosing control unit is in constant communication with the engine ECM through a data communications line. Before servicing this unit, the DCU must be disconnected from the battery before installing or removing the electrical connectors. The DCU is mounted on a bracket attached to the inside of the right frame rail near the diesel exhaust fluid tank.

Dosing Control Unit

CAUTION ***Disconnect battery before removing or installing electrical connectors. DO NOT use battery disconnect switch.***

Diesel Exhaust Fluid (DEF) Tank. The DEF Tank is a 15 gallon medium-high density polyethylene tank. This tank is designed to hold 15 usable gallons of DEF. The usable amount of fluid in the tank is displayed in the instrument panel's driver information panel as a percent of DEF in the tank. The tank fill neck has a 19 mm diameter restrictor to prevent inserting a diesel fuel fill nozzle. The tank is also designed to prevent overfilling. When the tank is full there will be approximately 10% empty space at the top of the tank for fluid expansion due to temperature. If the fluid level in the tank drops to 10% the driver will be notified with a priority message in the instrument panel accompanied by a warning light (see *DEF Levels of Notification*). The feed line in the tank has a serviceable 100 micron filter. This filter is back-flushed each time the bus is turned off due to a purge cycle (see *Purge Cycle*). The tank also has a heater which uses engine coolant to regulate the temperature of the DEF. When the outside temperature is below 11°F the tank heater will maintain a minimum temperature of 21°F during operation. Above this temperature the DEF will be maintained at ambient temperature. The tank also houses a fluid temperature sensor and a fluid level sensor. A multifunction head provides access to the DEF feed line, return line, and coolant lines as well as electrical connections to the two sensors. The tank is supported by a metal housing which is attached to the frame rail out rigging with four isolators. The tank and fill port are located on the right side of the bus near the entrance door. On Rear Engine models the DEF tank is located between the frames forward of the rear axle.

DEF Fill Door

DEF Fill located to the left of the entrance door.

Diesel Fill

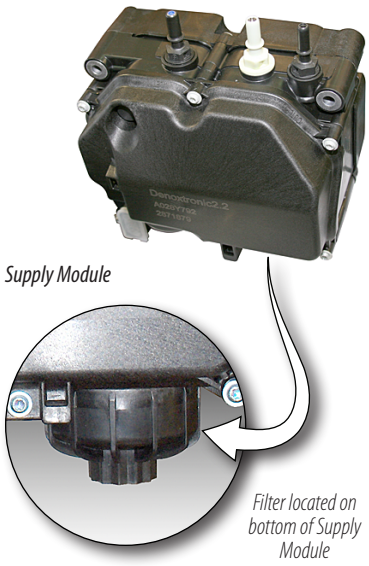
Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid (DEF) is a nontoxic, nonpolluting, non-hazardous and nonflammable solution. It is stable, colorless, and meets accepted international standards for purity and composition. DEF is safe to handle and store and poses no serious risk to humans, animals, equipment or the environment when handled properly. Refer to MSDS sheets currently available. DEF is a solution of 32.5% high purity urea and 67.5% de-ionized water. This ratio is critical due to the fact that both the urea and water will freeze together at 11°F. At this temperature both the urea and water will not only freeze, but thaw at the same rate, ensuring that as it thaws the fluid does not become diluted or over concentrated. This ratio is the ideal solution as it provides the lowest freeze point for both the urea and water, preventing degradation of the solution. Also, the SCR system is calibrated to the 32.5% ratio for optimum NOx reduction during operation. The DEF you purchase should state and display the certification of the American Petroleum Institute, German Institute for Standardization DIN70700, the International Organization for Standardization ISO 22241-1 and meet AUS – 32 specifications. This will ensure the proper purity and concentration. For more information on these specifications, visit *www.iso.org*. DEF packages will also have a date code located somewhere on the product. The first digit of the date code represents the fluid batch number and the next six digits reflect the date that the batch was filled.

During bus operation, the SCR system is designed to provide heat for the tank and supply lines. If the DEF freezes during shut down, starting and normal operation of the bus will not be inhibited. The system is designed to quickly return the DEF to a liquid state and the operation of the bus will not be impacted.

CAUTION ***Anti-gelling or freeze point improvers or additives of any type are not approved for DEF. Any further blending or adjusting of the DEF mixture will impede its ability to perform correctly and may cause damage to the SCR components.***

DEF should be stored in a cool, dry, well-ventilated area, out of direct sun light. The shelf life is a function of ambient storage temperatures. DEF will degrade over time depending on temperature and exposure to sunlight. The optimum storage temperature is up to 77° F (25° C) where shelf life will be greater than two years. DEF stored between 10° and 90° F will have a shelf life greater than one year. DEF can be tested using a refractometer designed for this purpose.

Supply Module. The Supply Module is part of a high accuracy system for injecting diesel exhaust fluid into the exhaust aftertreatment system. It has a 12V electronically operated pump and metering system, controlled by the DCU, which delivers diesel exhaust fluid to the Dosing Module mounted in the exhaust system downstream of the diesel particulate filter. The Supply Module has two filters, a 100 micron inlet filter and a 10 micron main filter which is serviceable. The Supply Module and Dosing Module system is designed to deliver a precise amount of DEF solution by weight into the exhaust system according to capacity, which is calculated by an external algorithm. The Supply Module also houses a heater and temperature sensors to thaw and keep the DEF in a liquid state during cold temperatures, a pressure sensor to regulate the output pressure to 130 psi and a reverting valve that clears the fluid lines during shut down (see *Purge Cycle*). The Supply Module is attached to a bracket on the inside of the frame rail near the DEF tank.



Supply Module

Filter located on bottom of Supply Module

CAUTION ***When handling or storing the Supply Module, suitable precautions should be made to protect it from damage. If this component is dropped it should not be used.***

Dosing Module. The Dosing Module is mounted to the decomposition reactor and is used to add diesel exhaust fluid to the exhaust stream. DEF is supplied to the Dosing Module from the Supply Module through a pressure line with an operating pressure of 130 psi. When needed, the DCM will activate the Dosing Module which will introduce a fine mist of DEF to the exhaust stream. The DEF is supplied to the Dosing Module at an operating temperature between 23°F and 158°F. Because this is part of the exhaust system, temperatures can become extremely hot which would cause the DEF to vaporize. To prevent this from happening, engine coolant is continuously circulated through the module while in operation. Coolant supply and return lines (3/8" SAE J2044 quick connect fittings) are provided and supply a minimum of 0.17 GPM at idle to a maximum of 2.0 GPM during bus operation. Care should be taken not to break or damage the plastic DEF pressure line fitting (5/16" SAE J2044 quick disconnect).

Dosing Module

CAUTION ***Never use the Dosing Module as a carry handle when servicing the Decomposition Reactor. Suitable precautions should be used to protect the Dosing Module from damage when storing and handling. The protective caps provided with the module should not be removed until final installation of the fluid lines. If this component is dropped it should not be used.***

Decomposition Reactor. The Decomposition Reactor is located downstream to the DPF between the DPF and SCR unit. It measures 19 inches long and has a diameter of five inches with a half inch of insulation making the outside diameter six inches. The Decomposition Reactor has an integrated diesel exhaust fluid diffuser inside the housing designed so that the ammonia contained in the injected DEF can decompose and be adequately mixed with the exhaust stream before it reaches the SCR Catalyst. The Decomposition Reactor is supplied with a Dosing Module already mounted on the reactor flange. The decomposition reactor assembly must be clamped and properly torqued to the DPF and SCR units using gaskets and full Marmon joints with "vee" band clamps to minimize leakage and heat loss, which is critical to the process. Never use the Dosing Module as a handle when picking up the decomposition reactor assembly.

Selective Catalytic Reduction (SCR) Device. The SCR device is comprised of a canister which contains a selective catalytic reduction catalyst and two temperature sensors. The temperature sensors are used to determine when the SCR unit has reached the required temperature to support the chemical reactions and allow diesel exhaust fluid dosing. An oxygen sensor is also mounted to the outlet section of the canister. The SCR catalyst uses Ammonia (NH3), contained in the injected diesel exhaust fluid and formed in the decomposition reactor, to react with the NOx in the exhaust stream. The catalyst prompts a chemical reaction combining the ammonia and the nitrogen oxides ($4NH3 + 4NOx + O2 = 4N2 + 6H2O$) to form harmless Nitrogen (N2) and Water (H2O). This reaction is temperature dependent therefore it is important that all insulation is intact and all connections are leak free. On the bottom of the canister is a moisture drain hole in the outlet section. Hot exhaust gas will escape the drain hole with temperatures reaching 300° F three inches radially outward from the holes exit during normal active regeneration. Be careful not to plug this hole or cover it with the mounting straps. Caution should be observed while working in this area with the engine running. To avoid damage to the SCR device only ultra low sulfur diesel fuel with a maximum sulfur content of 15 ppm.

Nitrogen Oxide (NOx) Sensor/Module. The NOx sensor is part of an assembly which includes the NOx sensor probe and NOx sensor control module. A 12v sensor cable attaches these components to form an assembly. There are two cable lengths available, 24.2 inch (615mm) and 36 inch (915mm) to accommodate variations in the configuration of the system. The cable should be anchored to insure cable temperature does not exceed 392 deg F (200 deg C). The NOx sensor probe is located on the outlet tube of the SCR device and is connected to an electronic control module mounted to the frame rail. The NOx sensor communicates with the engine ECU on the J1939 data link and continually monitors the NOx level leaving the SCR device ensuring that the emissions are compliant with the EPA 2010 standard by meeting or exceeding NOx removal at 0.2-g/HP-HR.

Diesel Exhaust Fluid (DEF) Lines. The diesel exhaust fluid lines carry DEF from the supply tank to the supply module which pumps the fluid to the dosing module. There are three DEF lines involved in supplying the pump a steady flow of fluid and supplying it to the dosing module. The Supply line from the tank to the Supply Module is called the Inlet or Suction line and is a 3/8" line with SAE J2044 quick connect fittings. This line is designed sufficiently rigid to prevent collapse due to a vacuum of up to 8.9 in. Hg (300 mbar) created during the suction event. The second line is the Throttle line which is the backflow line from the supply module. This line is also a 3/8" line used to return unused DEF to the tank. The third line is a 5/16" Pressure line which connects the Supply Module to the Dosing Module with SAE J2044 quick disconnect fittings. The Supply Module provides a pressure head of 130psi to the pressure line providing DEF to the dosing module for injection into the exhaust stream. This is a flexible line made of polytetrafluoroethylene (PTFE) allowing movement between the Supply Module and the Dosing Module. The line also has high thermal resistance withstanding temperatures up to 248° F (120C). All three lines offer excellent chemical resistance and are heated electrically with a series resistant heating circuit wrapped around the lines with a protective thermoplastic jacket.

Purge Cycle

The parts of this system vulnerable to freezing in the winter are the external lines and fittings between the supply module and the dosing module. Exposed lines and fittings will freeze and prevent diesel exhaust fluid from flowing. The purge cycle is necessary to protect the dosing system from expansion of the DEF during a hard freeze which would damage the dosing system components. During a purge cycle the supply module pumps the diesel exhaust fluid inside the supply, pressure, and throttle lines back into the DEF tank. This is done through a reverting valve located inside the supply module. Purging begins when the ignition is switched to the "Key Off" position and is completed in 60 seconds. This allows adequate time for the DEF lines to empty, protecting the dosing system components from damage due to thermal expansion of the DEF as a result of deep freeze conditions. Battery power must remain on during this process until the purge process is complete.

CAUTION ***Power to the Supply Module must remain on for 60 seconds after ignition is switched off to complete the purge cycle.***

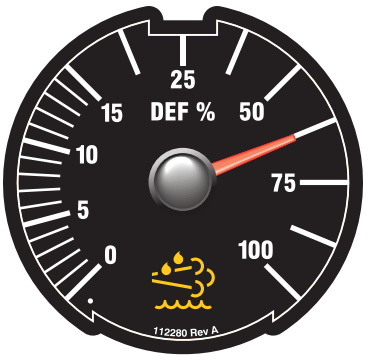
DEF Levels of Notification

A system of driver alerts keeps the driver informed of when the DEF is in need of service. When fluid is low or contaminated, several levels of alerts occur in sequence, each indicating a more imperative warning. When priority warnings occur, they will appear in Quad 1 of the Message Display in lieu of the odometer reading while Quad 3 indicates fluid level in the DEF tank at all times. The notifications are as shown below.

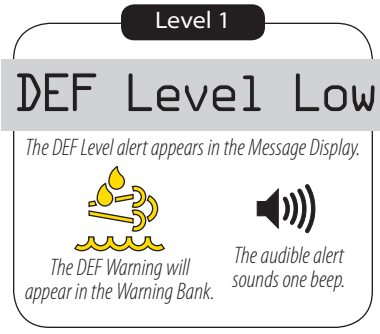
DEF Level 1. When the DEF level reaches 10% in the tank, a **DEF LEVEL LOW** warning will appear in Quad 1 of the Message Display at which point the amber DEF warning icon will appear in the lower left warning bank. This warning is accompanied with a single beep.

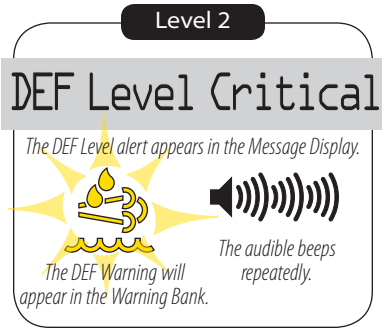
DEF Level 2. When the DEF level reaches 5% in the tank, a **DEF LEVEL CRITICAL** warning will appear in Quad 1 of the Message Display. The amber DEF Warning icon will commence flashing in the lower left warning bank. This warning is accompanied with repeating beeps.

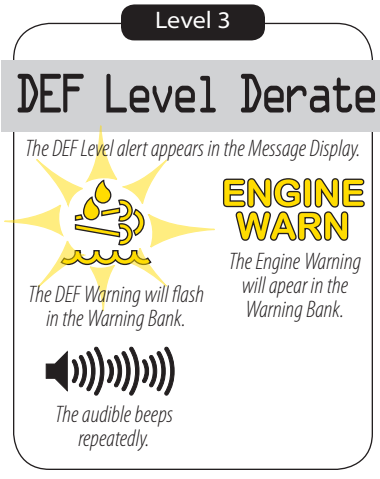
DEF Level 3. When the DEF level reaches 2.5% in the tank, a **DEF LEVEL DERATE** warning will appear in Quad 1 of the Message Display**.** The amber DEF Warning icon will continue flashing in the lower left warning bank and an addtional amber Engine Warning light will appear. At this point a 25% engine torque derate will occur.



Diesel Exhaust Fluid Level Gauge



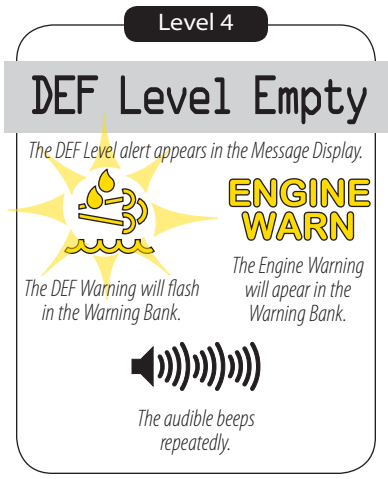


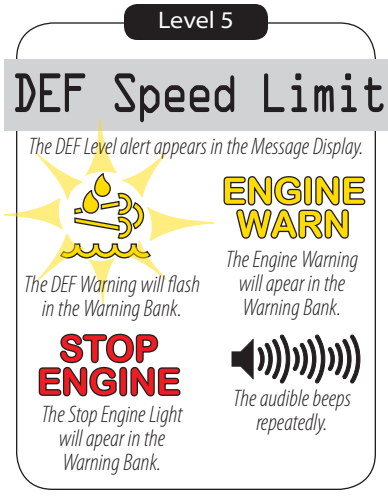


DEF Level 4. When the DEF level reaches 0% in the tank, a **DEF LEVEL EMPTY** warning will appear in Quad 1 of the Message Display**.** The amber DEF Warning icon will continue flashing in the lower left warning bank and an addtional amber Engine Warning light will appear. Continued 25% engine torque derate.

DEF Level 5. When DEF sytem can no longer maintain pressure, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display**.** The amber DEF Warning icon will continue flashing in the lower left warning bank. The amber Engine Warning light will remain illuminated and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be imposed with the 25% engine torque derate.

To automatically clear all DEF Level alerts, fill the DEF tank with approved API certified DEF fluid to a level greater than 10%. This can be verified by the DEF level gauge located on the instrument panel.





DEF Type Level 1. When incorrect fluid or mixture is introduced into the tank, a **DEF FLUID TYPE** warning will appear in Quad 1 of the Message Display**.** The integrity of the DEF solution needs to be checked using a refractometer. DEF system service should be attained within 10 hours or a level 2 alert wil be activated.

DEF Type Level 2. After 10 Hours at level 1, the **DEF FLUID TYPE** warning remains in Quad 1 of the Message Display and the amber Engine Warning light will appear in the lower left warning bank. At this point a 25% engine torque derating will occur. DEF system service should be attained within 10 hours or a level 3 alert wil be activated.

DEF Type Level 3. After 10 Hours at level 2, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display**.** The amber Engine Warning light will remain illuminated and and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be introduced with the 25% engine torque derate.

Level 1

The DEF Type alert appears in the Message Display.

Level 2

The DEF Type alert appears in the Message Display.

The Engine Warning will apear in the Warning Bank.

Level 3

The DEF Type alert appears in the Message Display.

The Engine Warning will apear in the Warning Bank.

The Stop Engine Light will appear in the Warning Bank.

There are six SCR System Fault messages which can be displayed when an active fault is identified. Each of these messages has a Level 1, Level 2 and Level 3 notification. The conditions which trigger each of these notification Levels are outlined below and follow the same format. The six SCR SYSTEM FAULT messages which are actually displayed are:

- DEF Tank Level Sensor Disconnected
- DEF Line / Dosing Valve Blocked
- DEF Dosing Valve Disconnected
- DEF Pump Disconnected
- SCR Harness Disconnected
- NOx Sensor Disconnected

SCR Fault Level 1. When an SCR System Fault is detected, a SCR SYSTEM FAULT MESSAGE warning will appear in Quad 1 of the display, this SCR SYSTEM FAULT MESSAGE will flash from positive to negative. The amber Engine Warning light will appear in the lower left warning bank. Engine diagnostic codes should be recorded and appropriate repairs should be made. DEF system service should be attained within 10 hours.

SCR Fault Level 2. After 10 Hours at level 1, the SCR SYSTEM FAULT MESSAGE warning will continue to flash from positive to negative and the amber Engine Warning light *WILL* remain illuminated and a 25% engine torque derate will occur. DEF system service should be attained within 10 hours or a level 3 alert will be activated.

SCR Fault Level 3. After 10 Hours at level 2, the SCR SYSTEM FAULT MESSAGE warning will continue to flash from positive to negative and the amber Engine Warning light will remain on and the Stop Engine light WILL be illuminated. At this point a 5 MPH speed limit will be introduced with a 25% engine torque derae.

Level 1

The SCR Fault alert appears in the Message Display.

ENGINE WARN

The Engine Warning Light will appear in the Warning Bank.

Level 2

The SCR Fault alert appears in the Message Display.

ENGINE WARN

The Engine Warning Light will appear in the Warning Bank.

Level 3

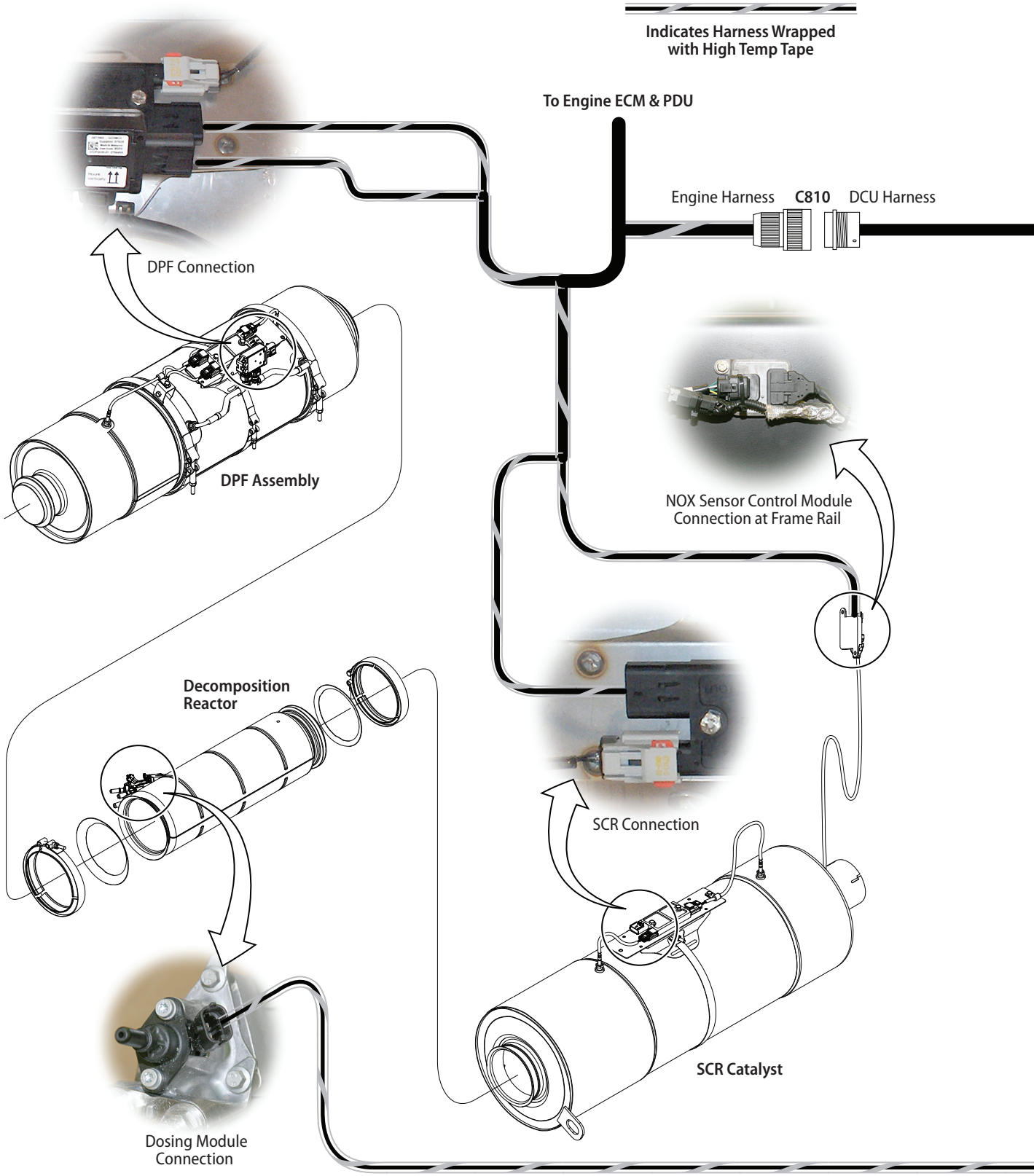
The SCR Fault alert appears in the Message Display.

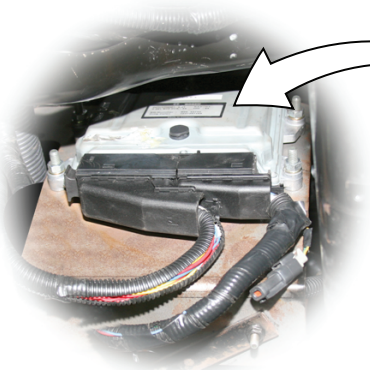
ENGINE WARN

The Engine Warning will apear in the Warning Bank.

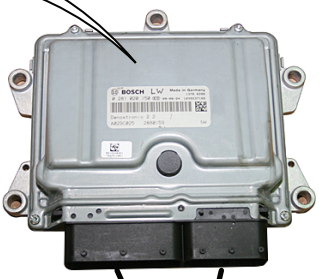
STOP ENGINE

The Stop Engine Light will appear in the Warning Bank.

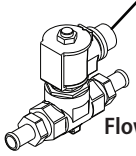

Indicates Harness Wrapped with High Temp Tape
To Engine ECM & PDU
Engine Harness
C810
DCU Harness
DPF Connection
DPF Assembly
NOX Sensor Control Module Connection at Frame Rail
Decomposition Reactor
SCR Connection
SCR Catalyst
Dosing Module Connection



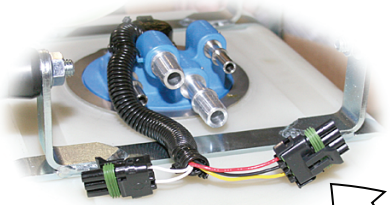
DCU Module Connection viewed from under bus



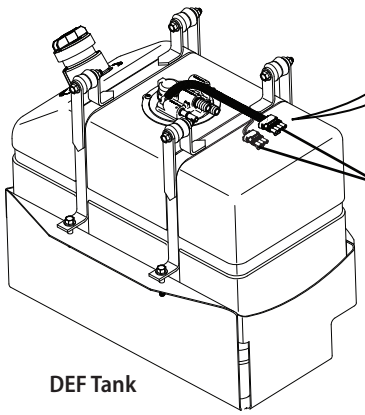
DCU Module



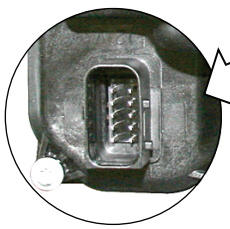
Flow Control Valve



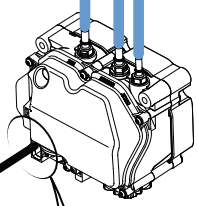
DEF Tank Harness Connection



DEF Tank



DEF Supply Module Connection



DEF Supply Module

INLET Port - From Suction Port on DEF Tank — DEF Fluid

BACK FLOW Port - To DEF Throttle Port on DEF Tank — DEF Fluid

OUTLET Port - DEF Pressure Line To Dosing Module — DEF Fluid

Heater

Heater

Heater

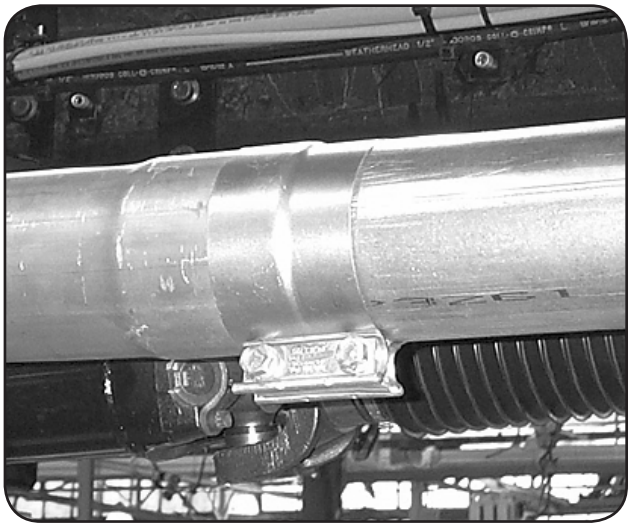
Exhaust, SCR Aftertreatment Harness

Exhaust Piping

The exhaust system is designed to move hot exhaust gases from the engine, underneath and toward the rear of the bus, while preventing contamination of the passenger area. All pipes and connections must be inspected for leaks at least monthly to provide continued safe transport of passengers.

CAUTION ***Never work under a bus with the engine running. Never work under a bus until the wheels are chocked, to prevent movement in either direction.***

Although the exact configuration of exhaust pipe and tailpipe sections is dependent upon the wheelbase and body length of the particular bus, the pipe sections, joint clamps and suspension hangers are similar. As a general rule, to remove the exhaust system, or any part of it, start at the rear most hanger and work forward.



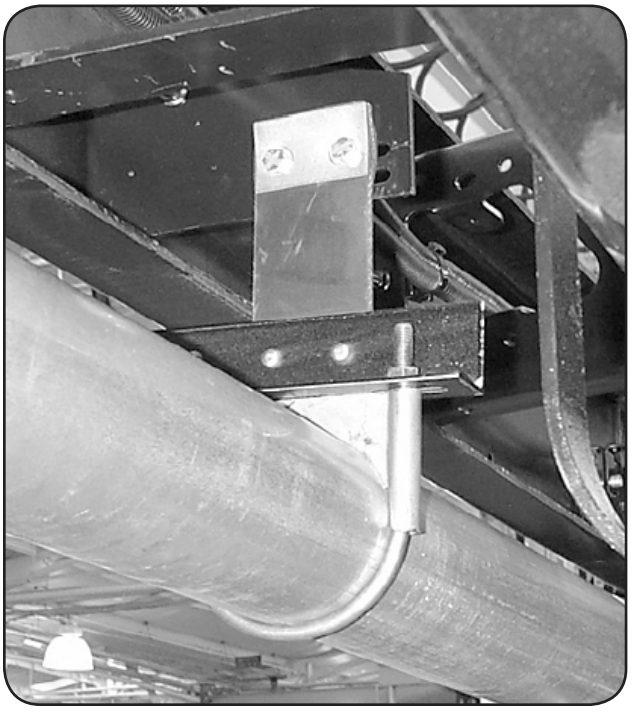
Typical Exhaust Clamp

SCR/DPF Assembly Removal

This general procedure applies to all wheelbases. See Exhaust illustrations at rear of this chapter.

1. Start at the rear bumper and loosen all the sections forward until you reach the SCR.
2. Remove the clamp securing the tailpipe onto the SCR.
3. With the slack produced by loosening the section clamps rearward, remove the tailpipe section nearest the SCR.
4. Disconnect all electrical harnesses from the SCR, Decomposition Reactor, and DPF. See *Exhaust, SCR Aftertreatment Harness*, next page.
4. Loosen the nuts at the straps securing the SCR.
5. Loosen the Vee-Band clamp which secures the SCR to the Decomposition Reactor.
6. Support the SCR and remove the strap from the hanger.

Typical Exhaust Hanger



If it is necessary to continue removing exhaust system sections, proceed from the SCR toward the engine as far as necessary. Proceed to remove DPF in same manner as SCR.

DPF/SCR Assembly Reinstallation

When assembling the exhaust system, start at the forward most section and work toward the rear of the bus. Always use new clamps and hardware.

1. Assemble the exhaust pipe to the DPF/SCR assembly. Leave all connectors loose for final adjustment.

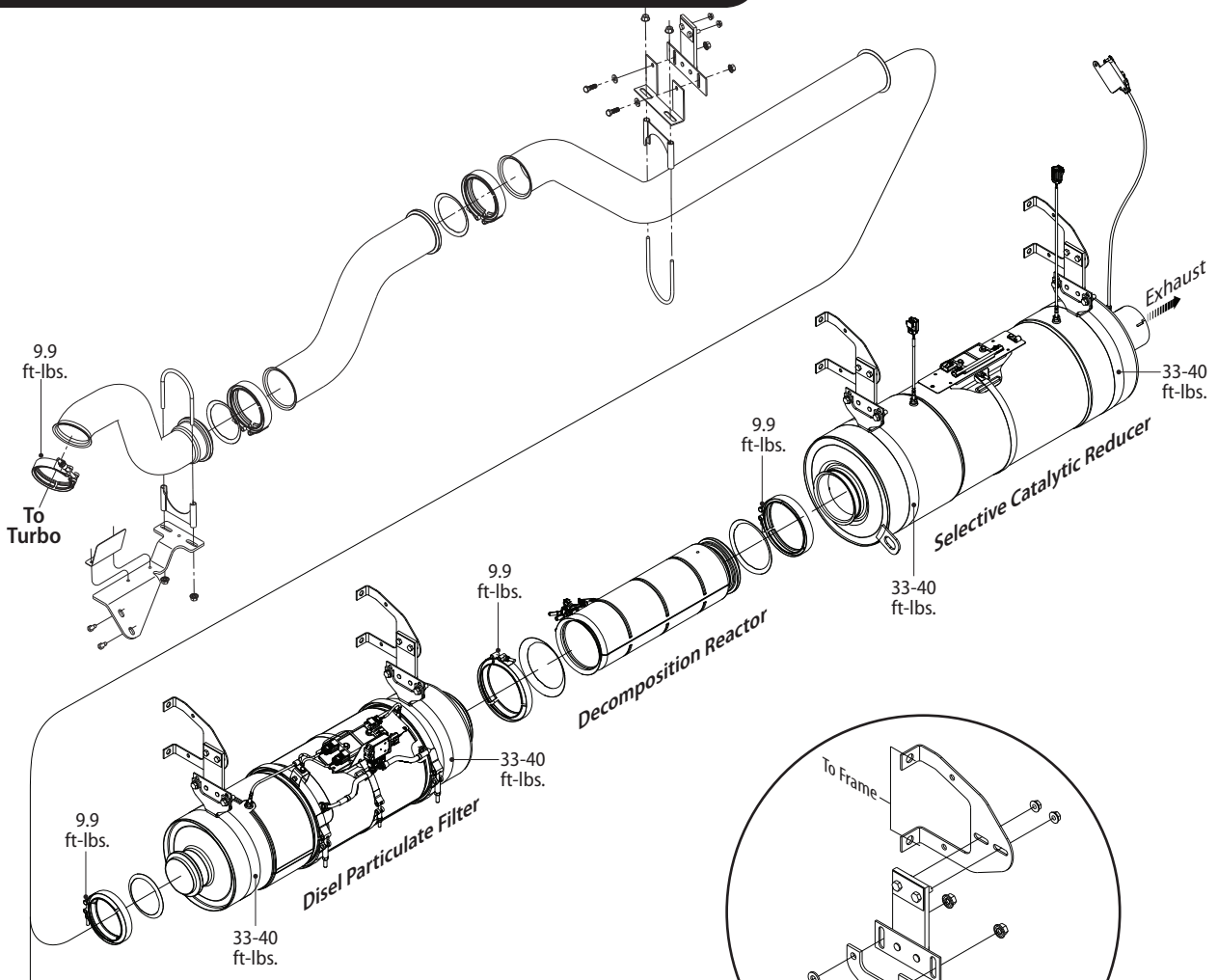
2 Use new wideband clamps, V-clamps,gaskets, and hardware.

3. Tighten the straps holding the DPF/SCR assembly.

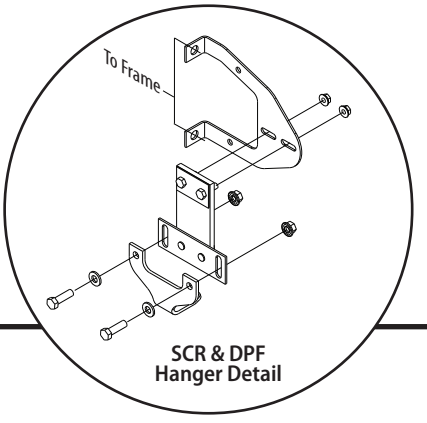
4. Continue working toward the rear of the vehicle. Leave all joints loose until the entire tailpipe assembly is in the correct position, and then tighten all the clamps.

Leak free, air tight connections are critical to prevent contamination of the passenger area and to insure proper operation of the SCR system.

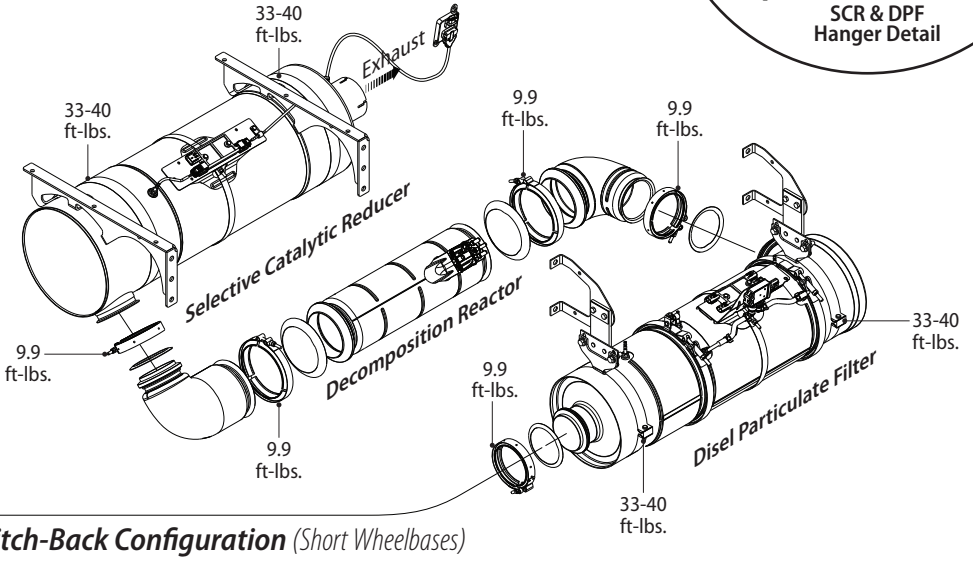
Exhaust, A3FE Primary, ISB10



In-Line Configuration *(Long Wheelbases)*

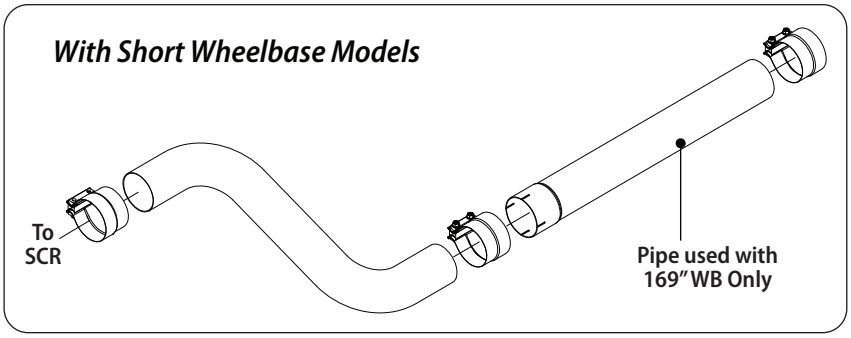


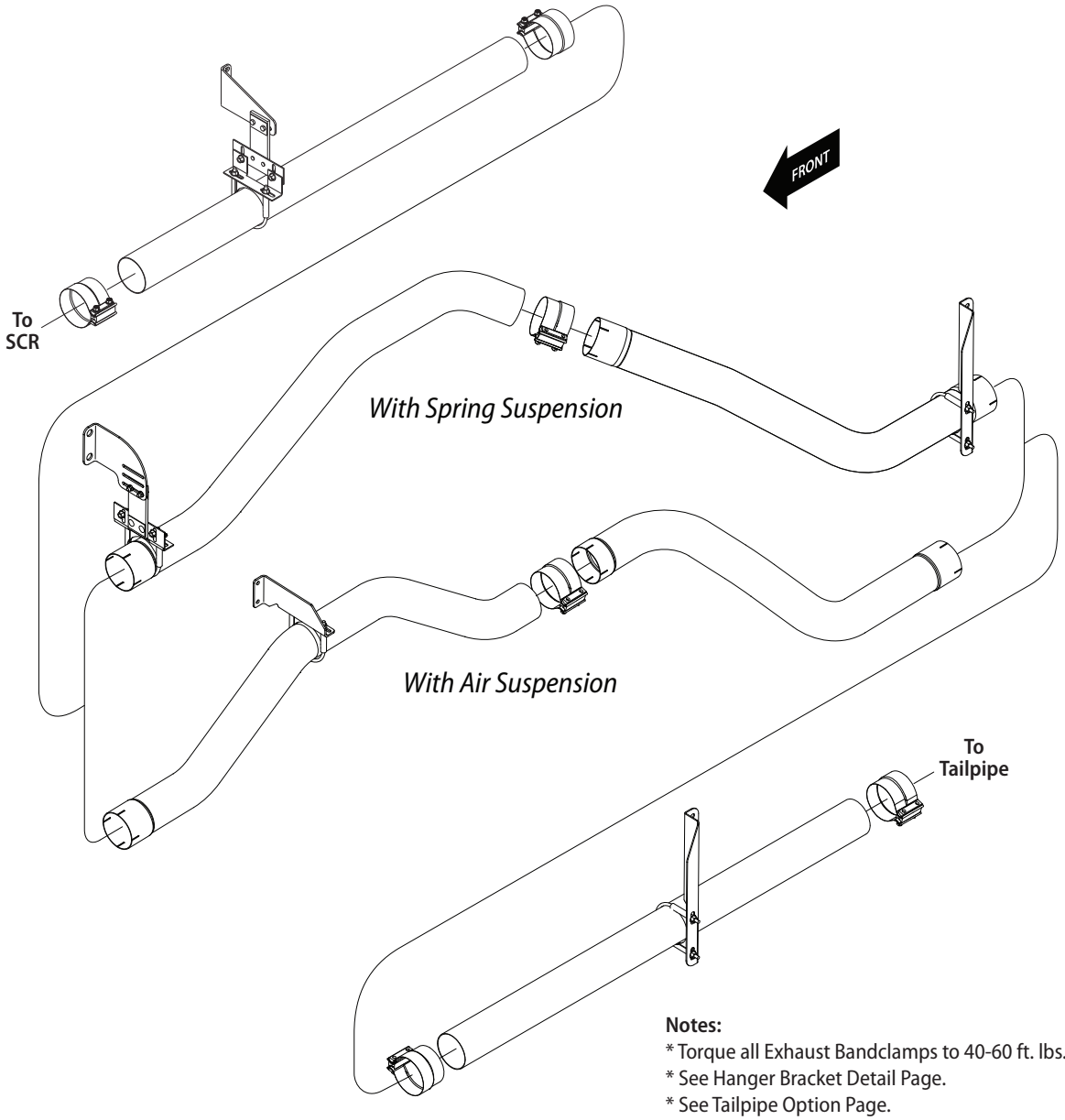
**SCR & DPF
Hanger Detail**



Switch-Back Configuration *(Short Wheelbases)*

D0004290c & D0004291c

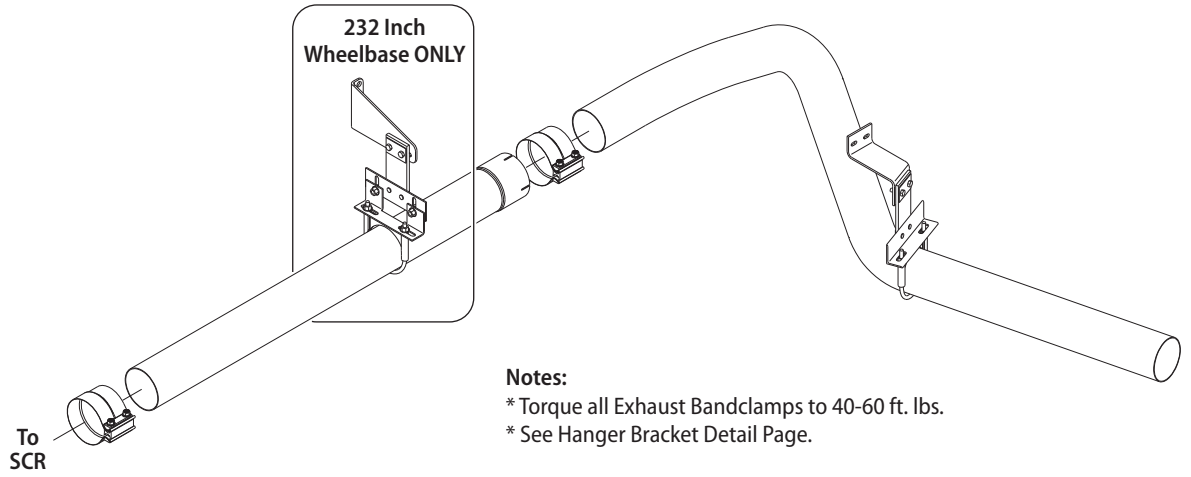




Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.
* See Tailpipe Option Page.

D0004300C & D0004301B

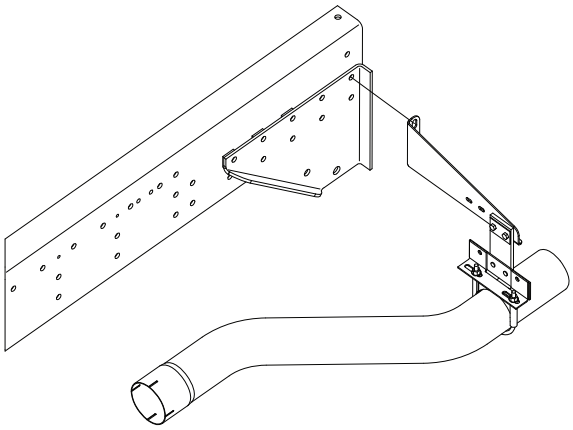
Exhaust, A3FE Secondary, ISB10



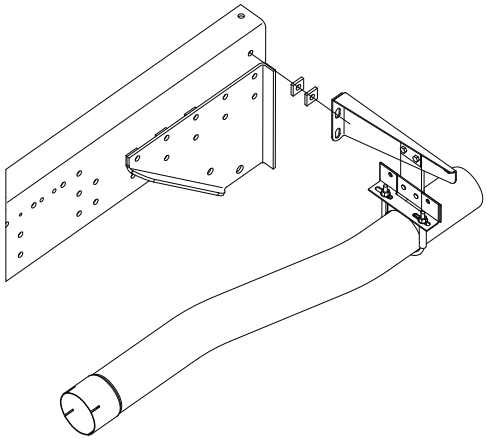
Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.

D0004302B

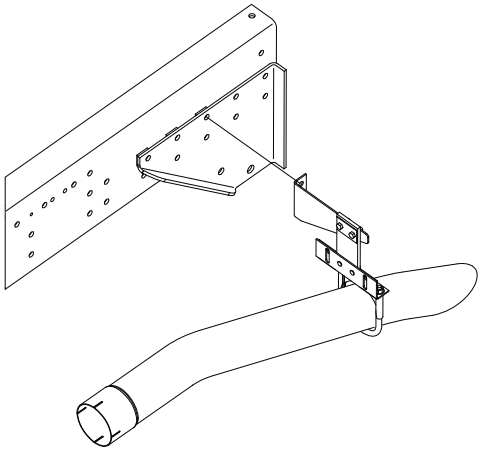
Exhaust, Secondary, ISB10 *(out the side)*



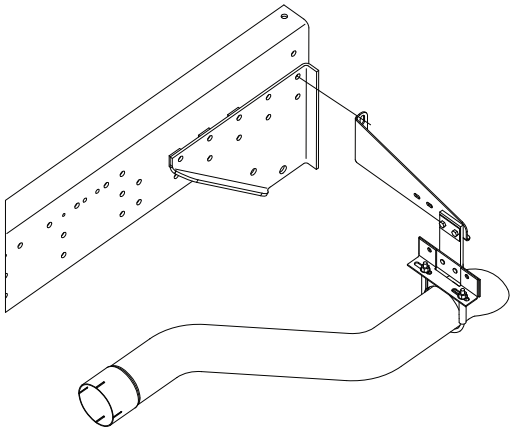
Tailpipe Under Bumper Option



Tailpipe Thru Bumper Option



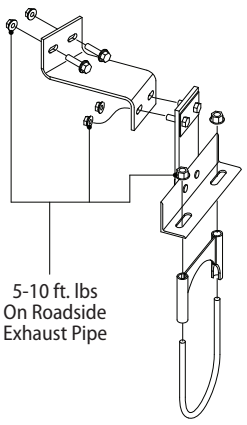
Tailpipe Turn Down Option

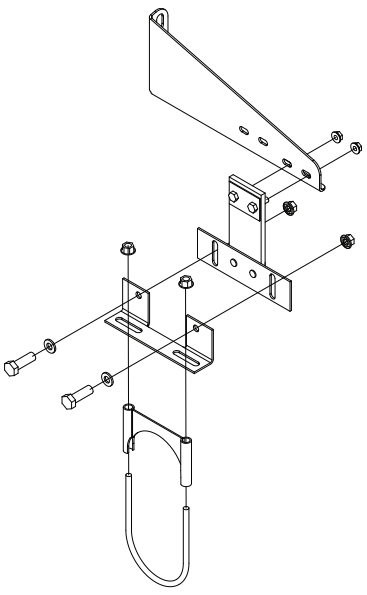


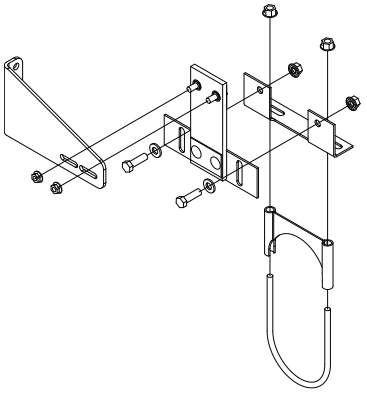
Tailpipe 90° Turn Down Option

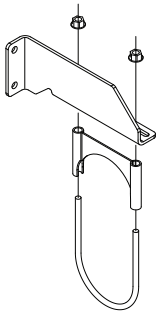
Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.

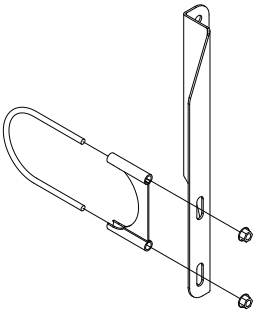
Exhaust, Tailpipe Options

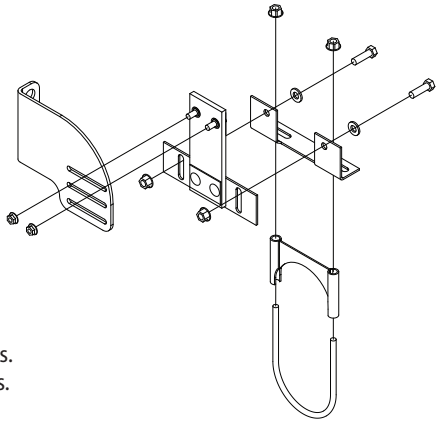






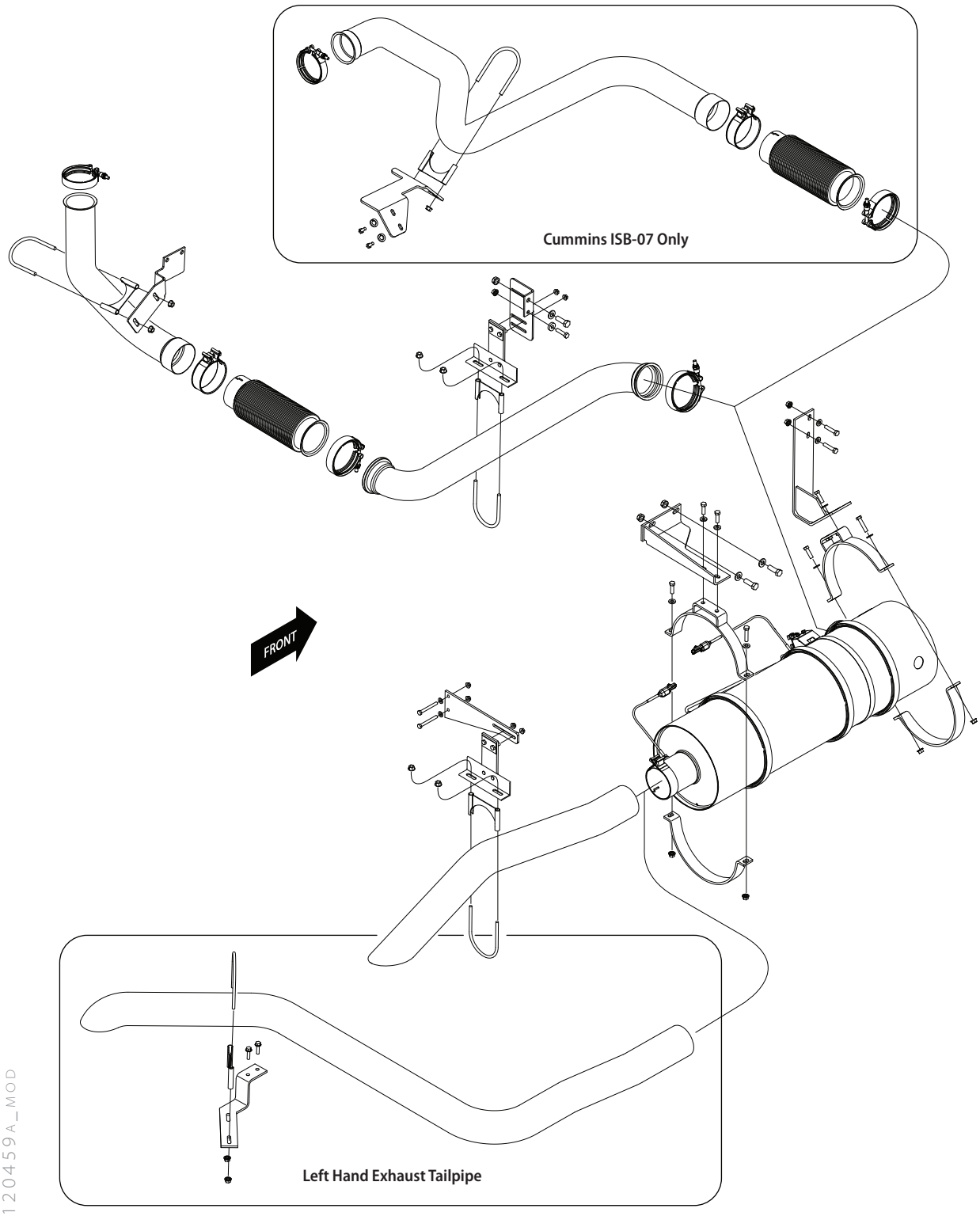






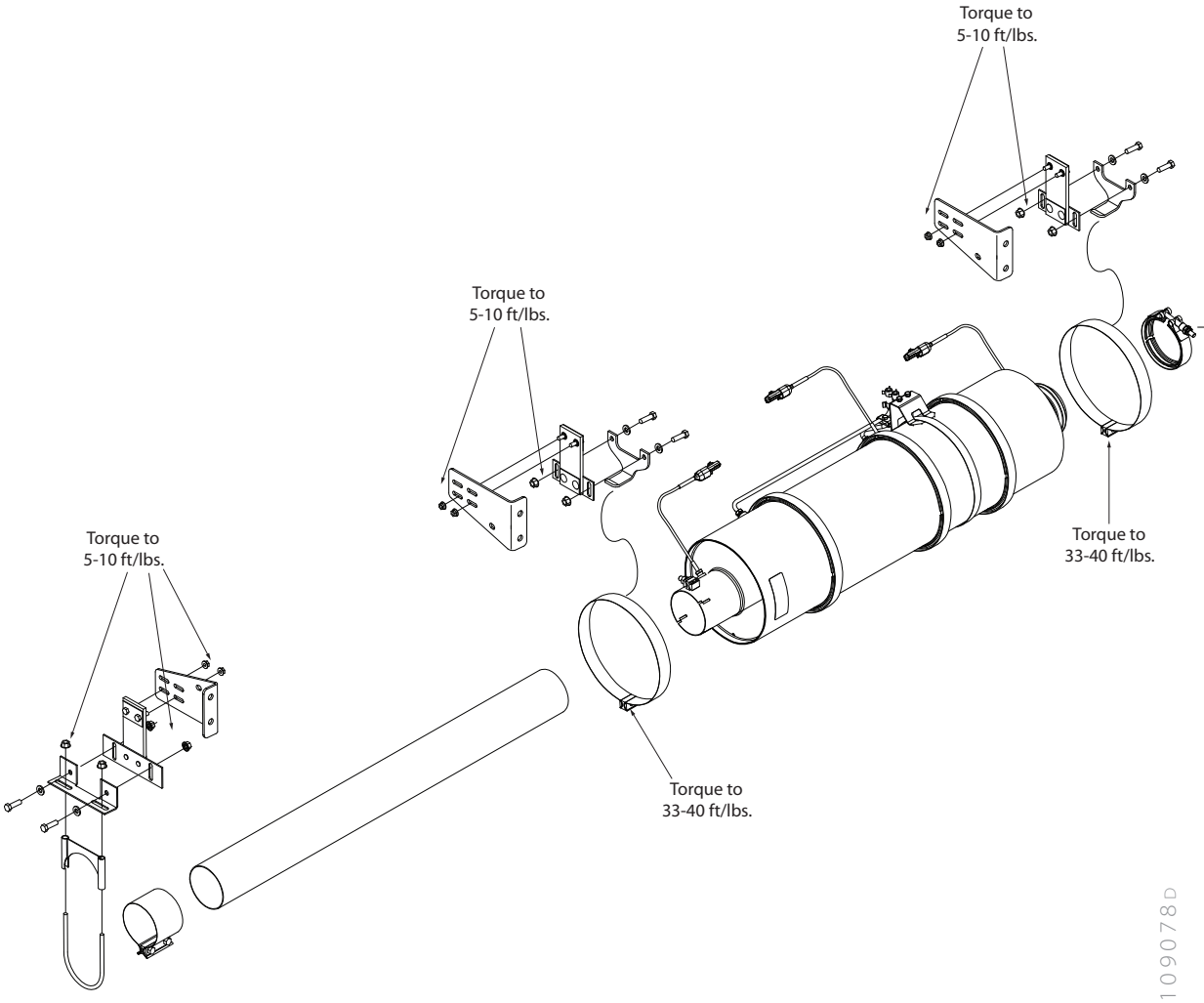
Notes:
* Torque all nuts at horizontally slot holes to 7-8 ft.lbs.
* Torque all nuts at vertically slot holes to 13-15 ft.lbs.
* Torque all U-bolt nuts to 13 - 15 ft.lbs.

Exhaust, Hanger Bracket Details



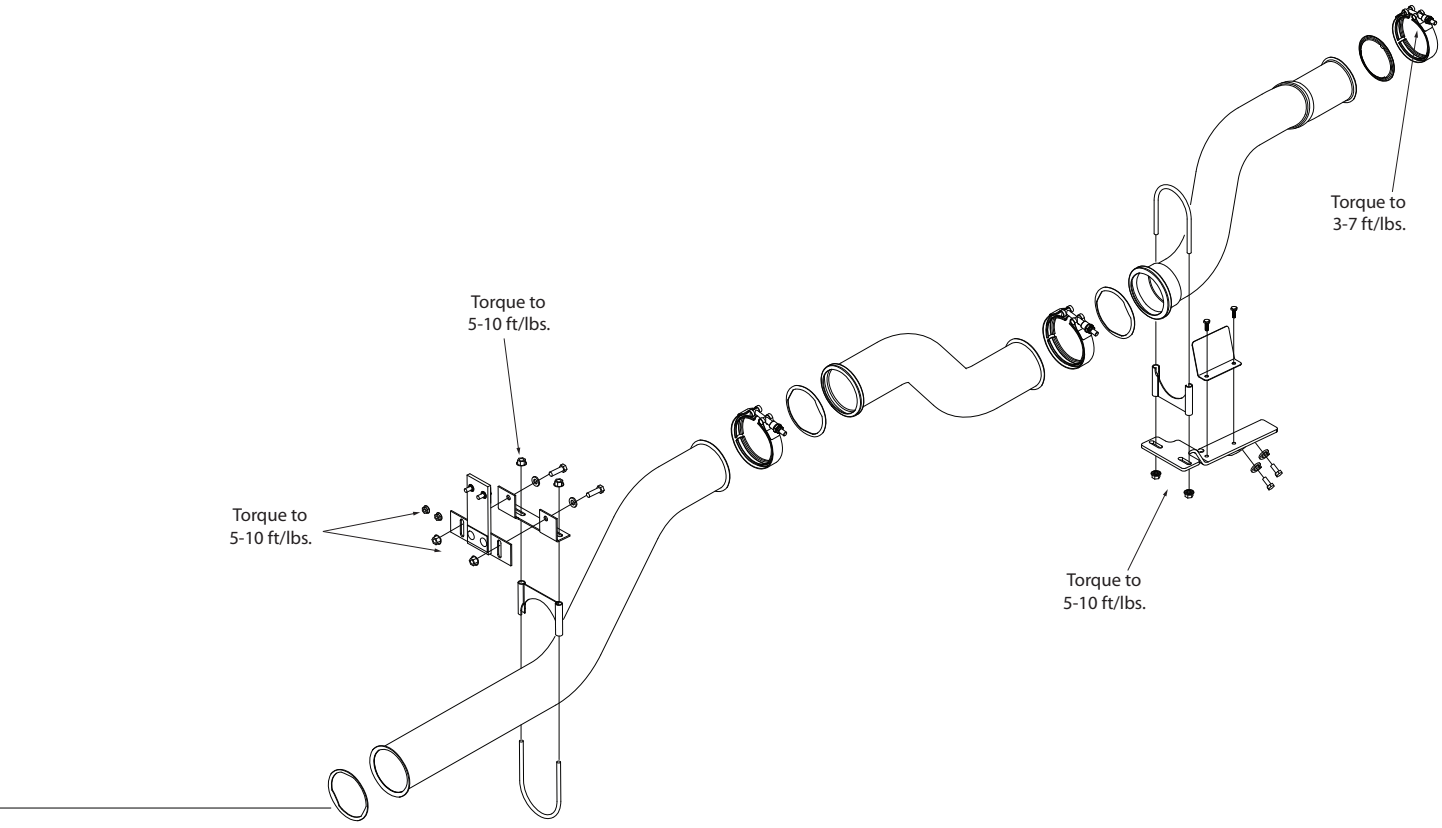
0120459A_MOD

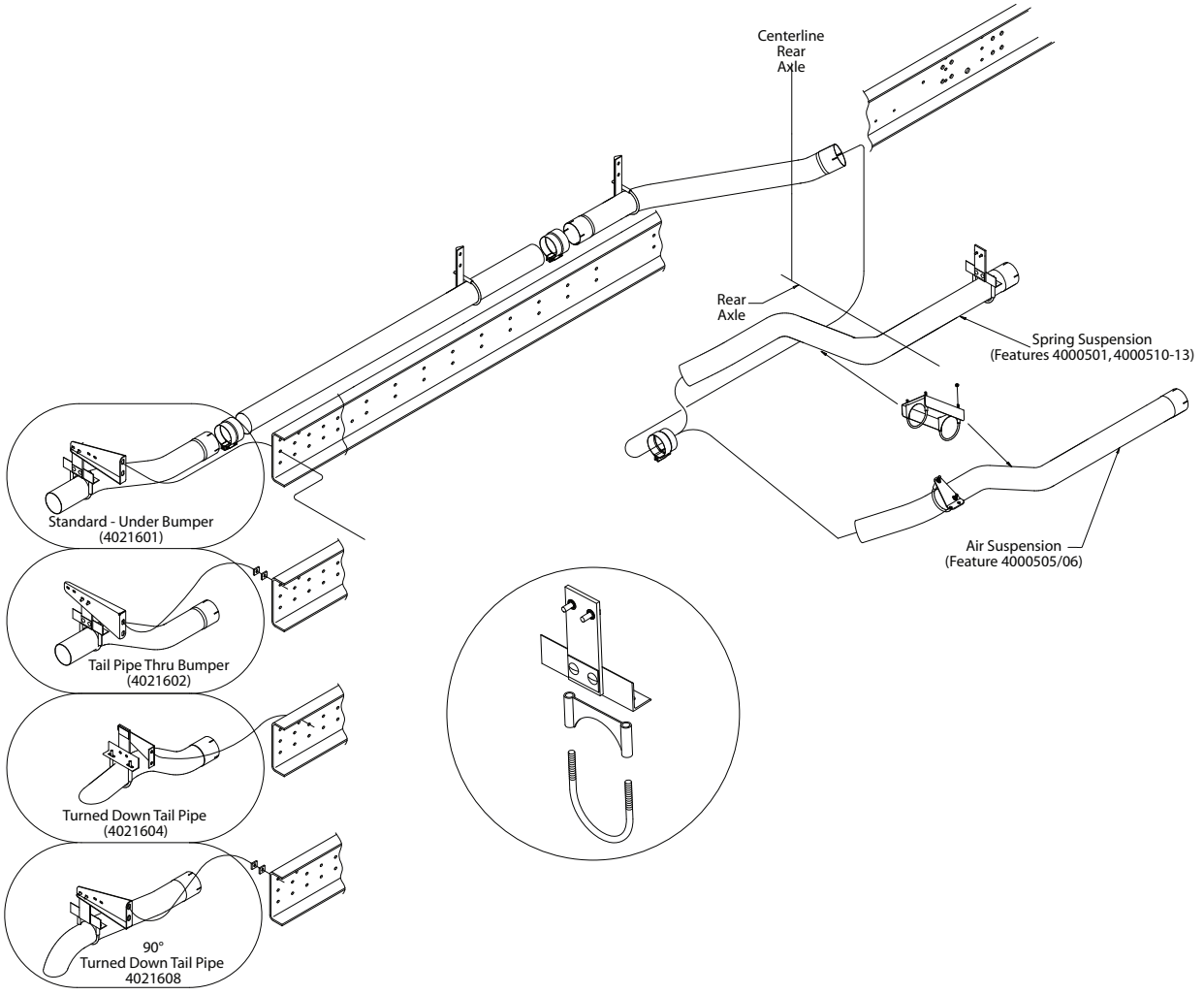
Exhaust: A3RE Cummins ISC & ISB (07)



0109078D

Exhaust, Main: A3FE With Cummins ISB07


Torque to
3-7 ft/lbs.
Torque to
5-10 ft/lbs.
Torque to
5-10 ft/lbs.
Torque to
5-10 ft/lbs.



0085324D

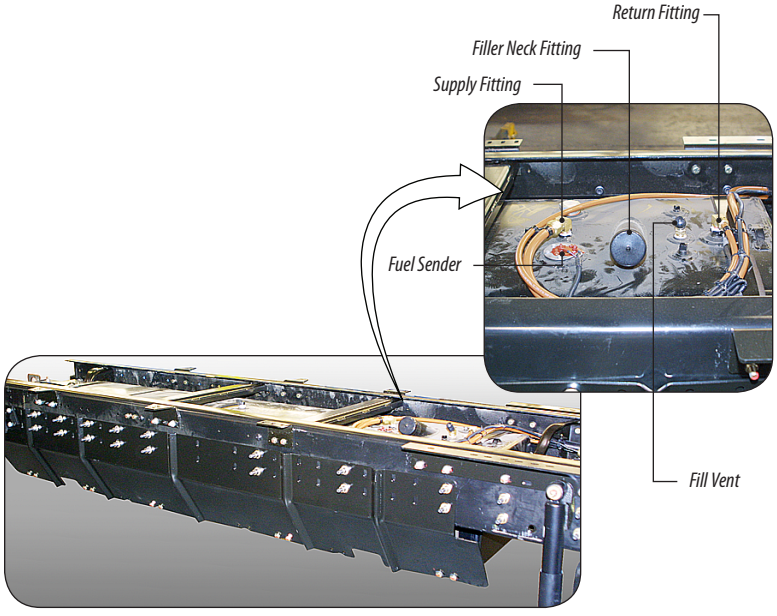
Exhaust, Rear: A3FE, ISB07

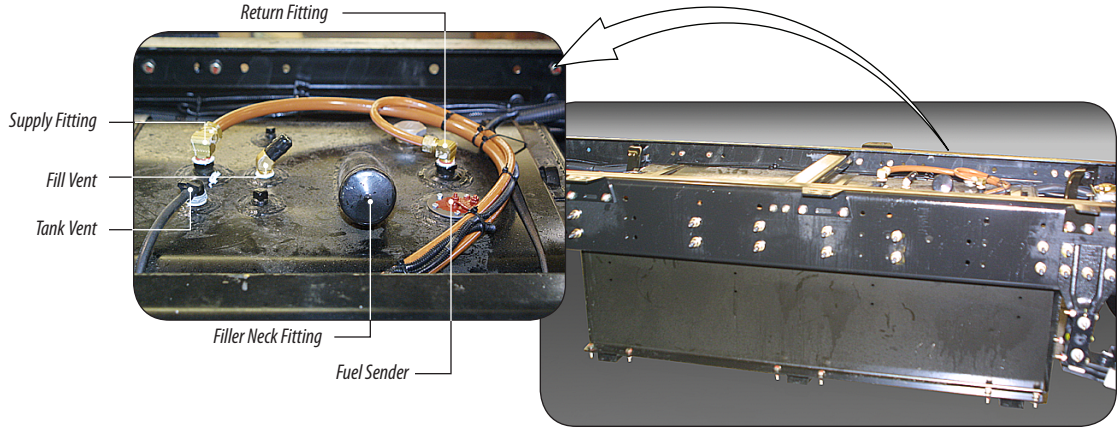
Fuel System

Fuel Storage

On most All American buses, the fuel tank is mounted between the frame rails and is surrounded for impact protection by a barrier system of steel panels and structural beams. On All American Rear Engine, the between-rails fuel tank is located rearward of the front axle. On All American Forward Engine, the between-rails fuel tank is located in the rear overhang, aft of the rear axle. Some All American Forward Engine buses have fuel tanks mounted outboard of the frame rails on the right side of the bus.

Fuel tanks of several capacities are available. All are rectangular tanks secured by a set of steel straps which surround the tank and mount to the barrier and support members. All tube fittings, filler necks, and sending units are mounted on the top of the fuel tank. An inspection port on the floor of the passenger compartment provides access to the fuel sending unit.





WARNING ***Blue Bird Product Engineering does not approve or disapprove additions to or modifications of Blue Bird fuel systems. Blue Bird fuel systems are designed and installed to meet federal standards and engine manufacturer's guidelines. The upfitter or modifier assumes all responsibility for vehicle engine and fuel system if the fuel system is modified.***

CAUTION ***In 2007 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications. In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.***

Fuel Filtration

It is critical to the high pressure fuel injection systems of modern diesel engines that fuel is free of contaminates and moisture. Diesel fuel serves to lubricate the injector pumps; any water in the fuel inhibits that lubrication and can lead to injector/pump failure. Therefore, dilligent inspection and maintenance of the fuel system filters is essential to engine longevity and performance.

Diesel-fueled All Americans are equipped with two stages of fuel filtration; a primary filter and a secondary filter, each with its own replaceable element. The primary filter is mounted by Blue Bird between the tank and the engine along the inside of the frame rail, it is a 10 micron filter and it and provides the first stage of filtration. The second stage of filtration is provided by a much finer filter (2-5 microns, depending upon specific engine) mounted on the engine by the engine manufacturer. Water separation occurs at either or both filters, depending upon which engine is installed. A manually-operated drain is provided to allow collected moisture to be expelled. The moisture collection trap(s) are equipped with electric heater elements to prevent accumulated water from freezing. The moisture trap may also be equipped with an electric water sensor, which causes a yellow warning light in the Driver's instrument panel to illuminate when water in the trap rises to a level sufficient to complete the circuit between the sensor's contacts. This indicates it is time to drain the contaminant collection bowl. After the water has been drained from the bowl, the yellow warning light resets.

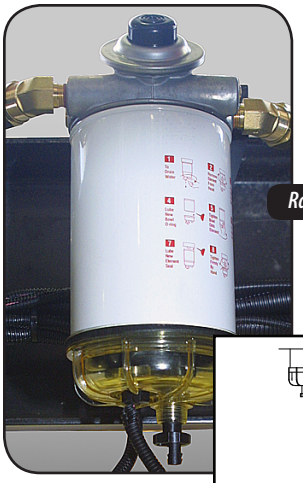
On All Americans equipped with Cummins ISB engines the primary filter is a Raycor filter/water separator unit with a replaceable spin-on element. The Raycor filter incorporates a see-through trap bowl which is equipped with a manually operated drain and electric heater.

The secondary filter is a Fleetguard unit mounted to the engine and equipped with water separation feature, a manual-operated water drain, electric heater, and electric moisture sensor.

On All Americans equipped with Cummins ISC engines the primary filter is a Fleetguard unit with a spin-on element, a manually operated drain, an electric heater element and a moisture sensor.

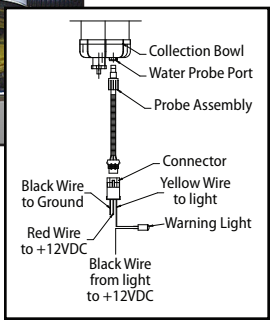
The secondary filter is a Fleetguard unit mounted to the engine and does not have its own water-separation feature.

Consult the engine manufacturer's Operators Manual, supplied with the bus, regarding maintenance schedules and replacement cartridges for the secondary filter. Blue Bird recommends using only OEM replacement filter elements.



Raycor Primary Fuel Filter

Cummins ISB



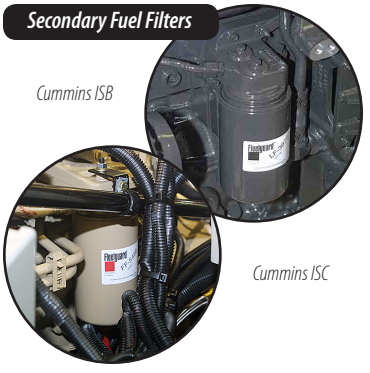
Optional Water Level Sensor

Raycor Primary Fuel Filter

Cummins ISC

Secondary Fuel Filters

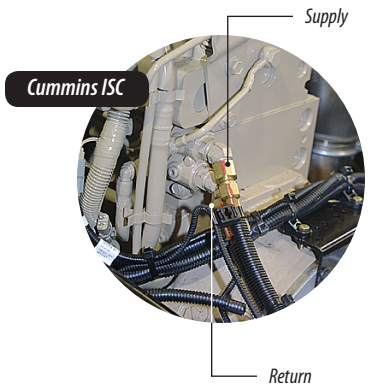
Cummins ISB



Cummins ISC

Fuel Delivery

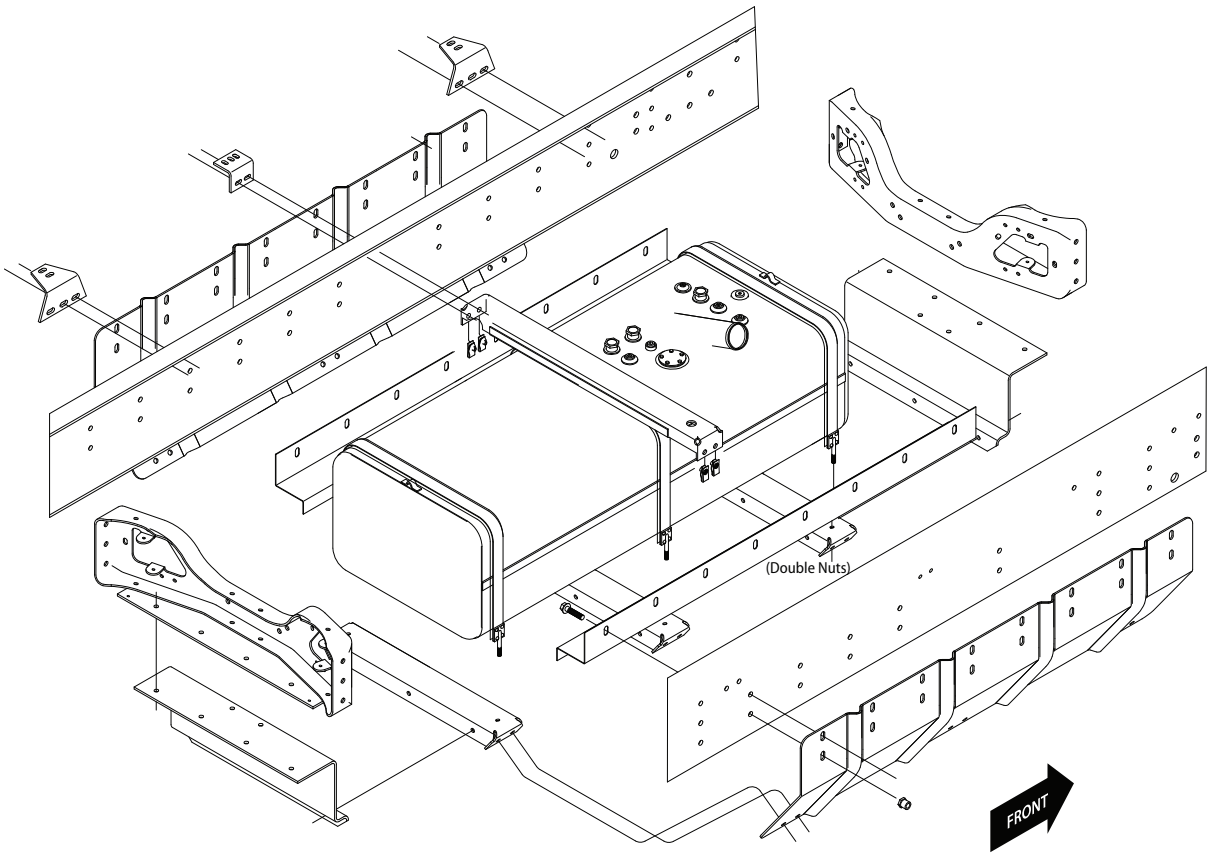
The fuel delivery systems on Cummins engines employs two pumps: The "transfer pump" draws fuel from the tank, through the frame-mounted Raycor filter, and into the engine supply port. The fuel then passes through a cooling coil mounted between the engine ECM and the engine. Thus, fuel is used as a cooling agent to reduce the temperature of the Electronic Control Unit. Leaving the ECM cooler, the fuel passes through the engine-mounted secondary filter and then enters a second, high pressure pump. The high pressure pump delivers the fuel under increased pressure to the Cummins Common Rail fuel delivery system. The portion of the fuel flow not used by the injectors continues on its way back to the engine's fuel return port, where a 1/2" OD fuel line conveys it back toward and into the top of the fuel tank.

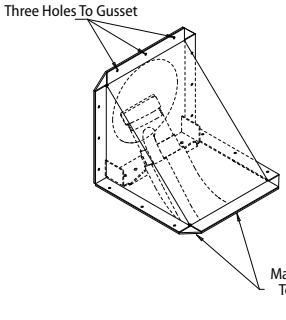


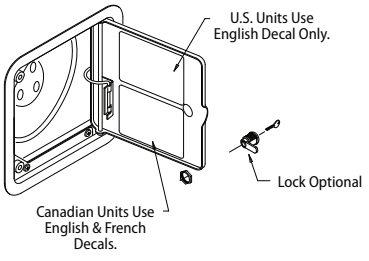
Fuel system delivery problems typically manifest themselves as symptoms such as failure to start, rough idling, rough running, etc. When a fuel-related problem is suspected, first check the Driver's dash panel warning lights for any light which would be generated by the ECM (Check Engine, Stop Engine, etc.) If any such lights are displayed, use the engine manufacturer's recommended electronic diagnostic tool(s) to obtain more detailed information about any stored error codes.

If no dash light errors are indicated, check the fuel delivery system components between the fuel tank and the engine's supply and return ports for possible causes such as clogged filters, water presence in the water separator bowl, leaking or otherwise damaged lines, etc.

If both filters and fuel system components external to the engine package have been eliminated as causes, but a fuel-related problem is still suspected, consult the engine manufacturer's service documentation for troubleshooting procedures.







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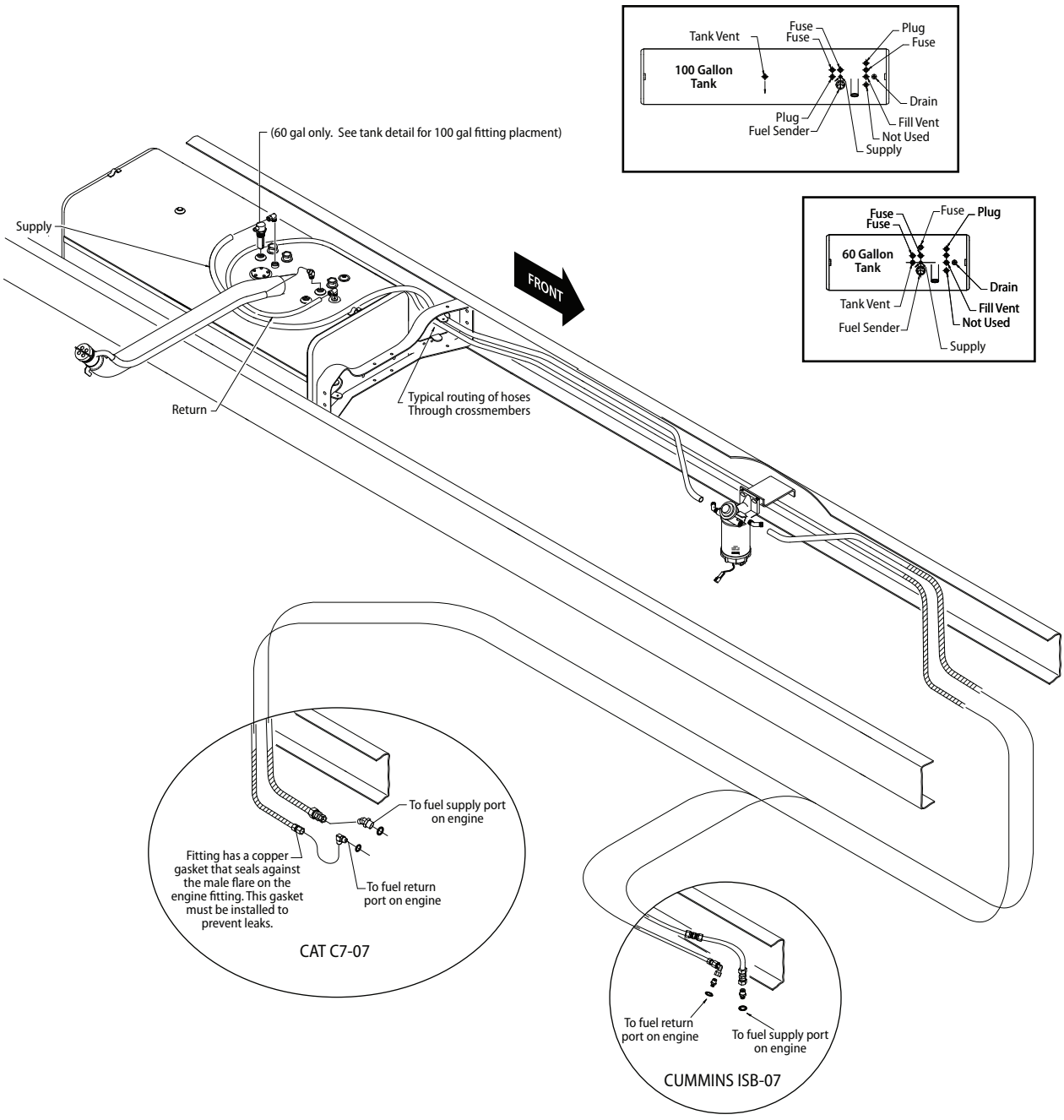
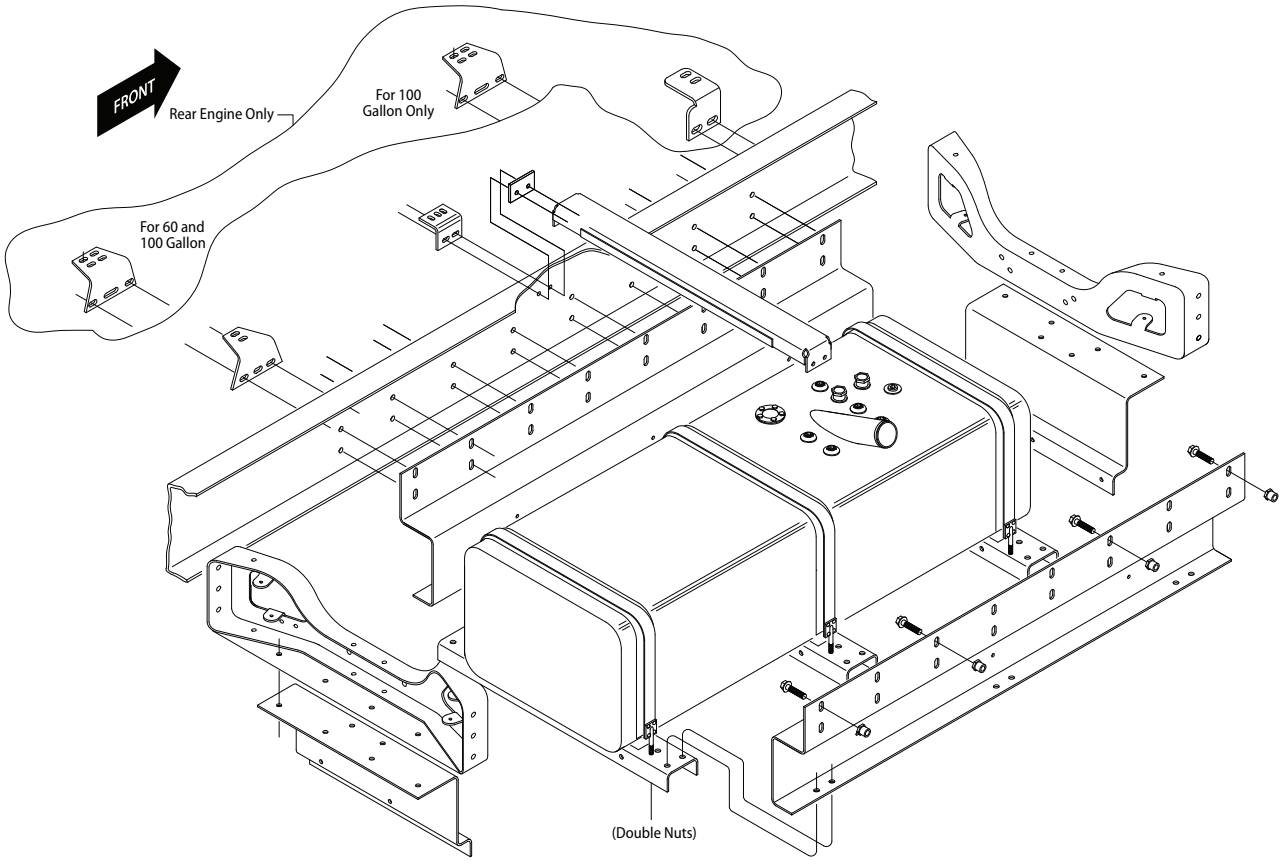
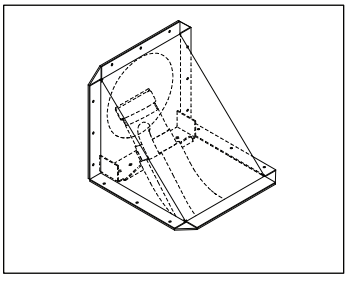
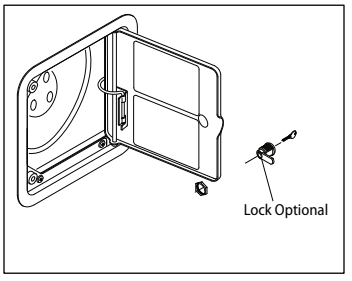
Fuel Tank & Barrier A3FE



Fuel System: A3FE







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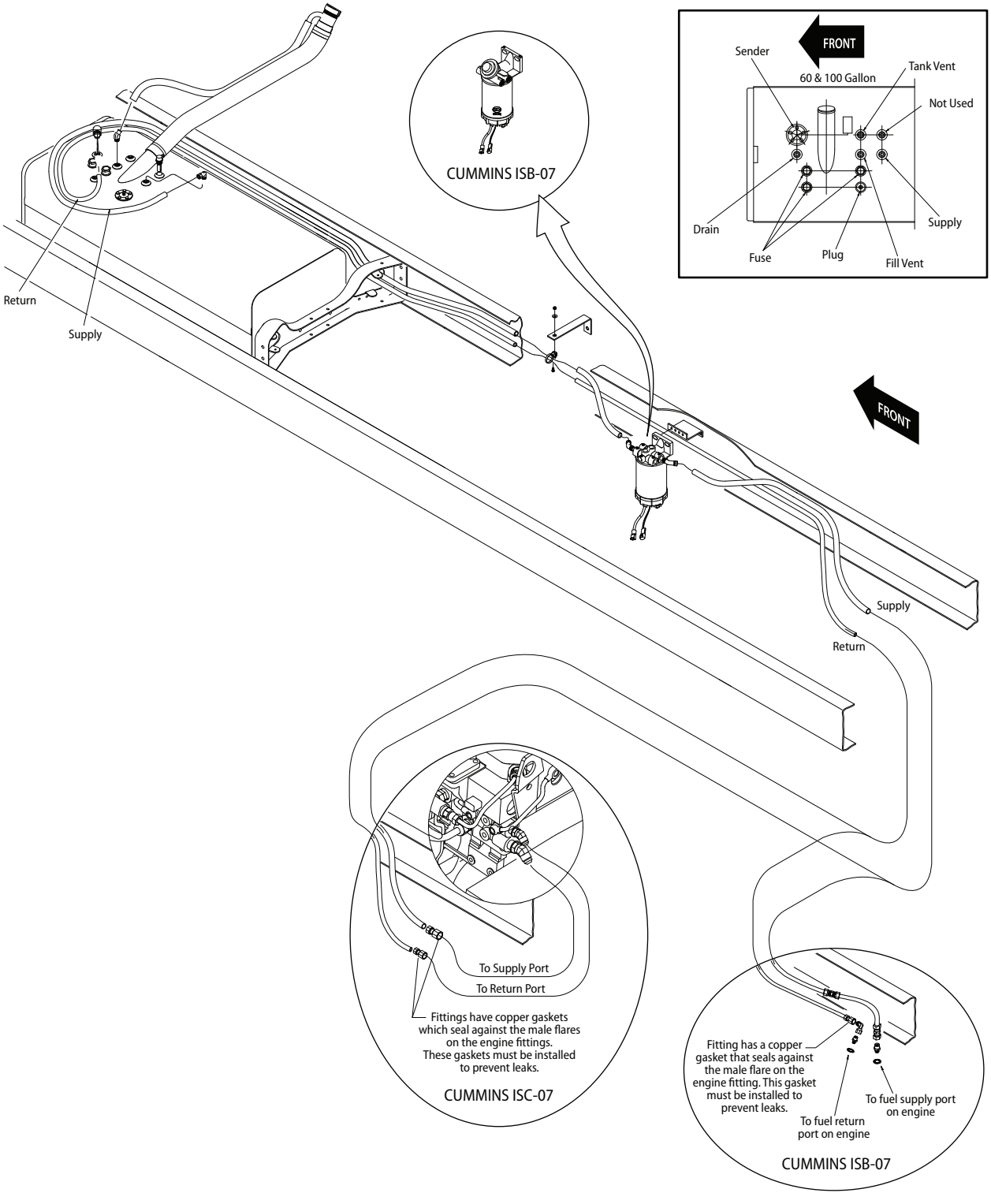
Fuel Tank & Barrier: A3RE



Fuel System: A3RE

Testing And Troubleshooting (Cummins)

The Cummins accelerator pedal incorporates two Throttle Position Sensors to provide the required input to the engine ECM. These components are non serviceable and should not be removed from the accelerator assembly or you could risk voiding the warranty. Each component has three wires going through a weather-pak connector and can be tested individually for proper operation.

Throttle Position Sensor Coil Resistance

The Throttle Position Sensor provides the engine an analog signal instructing it to increase or decrease RPM based on the position of the accelerator. This is done with a three wire potentiometer. The sensor is provided a continuous 5V DC (pin B27) and a ground (pin B28) by the engine ECU. As the accelerator pedal is depressed, the throttle position sensor will relay its position to the engine (pin B35). The throttle position sensor can be tested by the following:

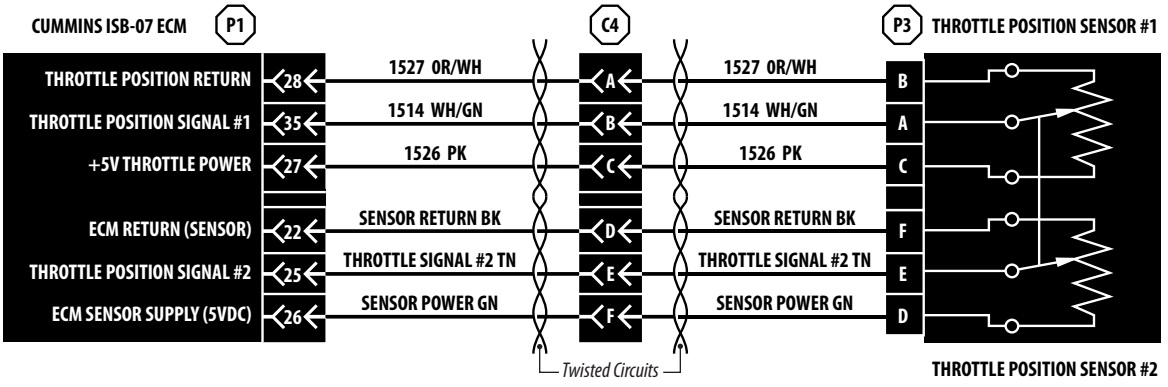
Disconnect sensor plug and meassure resistance on accelerator side of connector between:

- Pins C and A. (Supply and Return) Value should be between 2000 and 3000 ohms.
- Pins C and B. (Supply and Return) Released pedal value should be between 1500 and 3000 ohms.
- Pins C and B. (Supply and Return) Depressed pedal value should be between 200 and 1500 ohms.

Resistance should decrease proportionally as pedal is depressed. Released pedal resistance minus depressed pedal resistancemust be greater than 1000 ohms.

CAUTION ***Do not attempt to adjust or repair throttle position sensor or idle validation sensor. Warranty will be voided.***

Should the accelerator fail to meet specifications the entire pedal must be replaced.

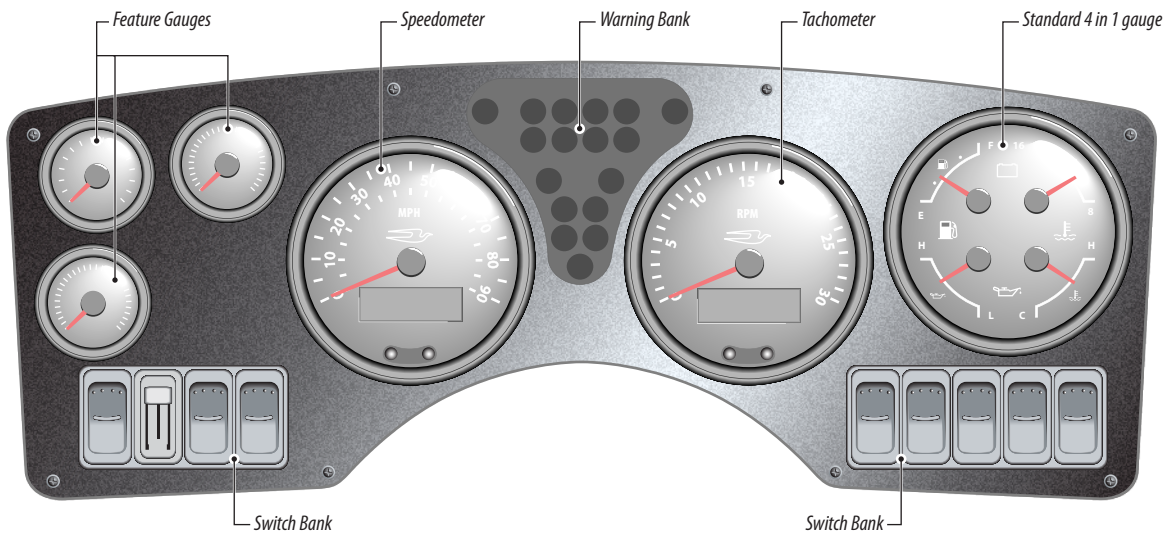


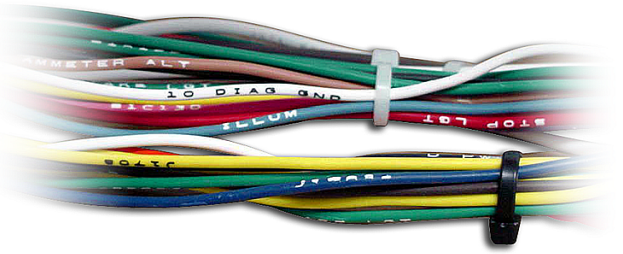
Overview

The Blue Bird All American instrument panel uses all electronic analog guages manufactured by ACTIA®. In addition to gauges, the instrument panel includes an LED display panel and gauge warning indicators which provide illuminated visual alerts to the Driver.

The instrument assembly receives both analog inputs from such components as the fuel tank sender and instrument panel dimmer switch; binary inputs from brake and directional signal switches; and digital signals from components such as the engine and transmission control modules, via the J1939 and J1587 data buses. The Warning Module also has ports to a built in transducer for primary and secondary air pressure signal lines on units equipped with air brakes.

The speedometer is the "master" gauge and serves as the central processor for the instruments' communication system. All of the other gauges are "slave" gauges connected to the speedometer on a common data bus. All gauges receive the same data stream. Each guage responds to its appropriate information within that data stream and "ignores" the rest. Therefore, data connectors on the backs of the various slave guages are interchangeable, and the proper operation of an individual guage is not dependent upon its being located in any particular position on the harness. The two four-pin connectors on the back of each slave gauge or panel are identical. This characteristic provides for a convenient and simple troubleshooting technique: Swapping the connector on a suspect guage with one on a properly performing guage, or jumpering between the connectors on the gauges, can help quickly determine whether a problem is in the gauge, harness, or in the data it is receiving.





Color coded and labeled wires

The speedometer also incorporates a backlit LCD Message Display Center, which can be used by the Driver or Service Technician to view vehicle statistics and fault alerts, and to perform self-diagnostics on the instrument system. The data to be displayed is selected by navigating a menu system controlled by two buttons on the face of the speedometer. (The tachometer incorporates a clock display similar in appearance to the speedometer's Message Display Center.)

The instrument panel also incorporates two switch panels to control such things as the high idol, lights and dimmer. These switches may vary depending on which options are on your bus. For troubleshooting convenience, the wires of the instrument panel harness are both color-coded and labeled.

Appendixes In This Chapter

Appendix 1. Service Gauge Operation. This ACTIA publication was created especially for Blue Bird and details the replacement of the instrument panel.

Instrument Panel Removal

The instrument panel is designed for easily removed from its housing by means of ten screws around the perimeter of its face plate. Individual gauges are fastened to the panel by a hand-tightened threaded ring around the back side of the meter's body.

1. Ensure the engine is not running and the ignition switch is in the "OFF" position.

2. Remove the ten machine screws from around instrument panel's perimeter.

3. Carefully pull the top edge of the instrument cluster away from the housing.

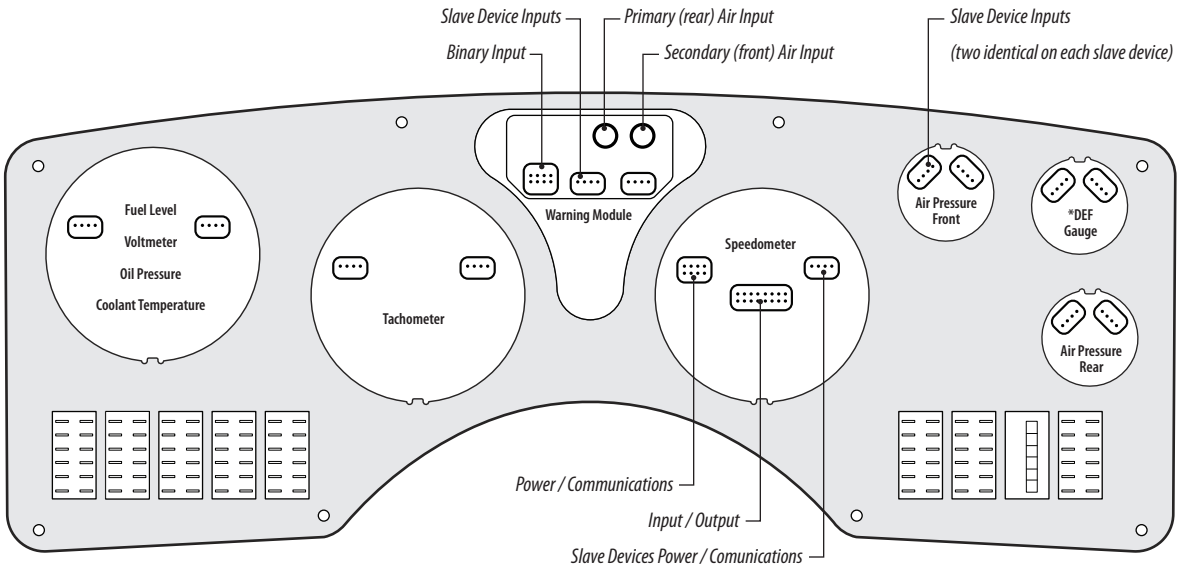
4. To remove a gauge, unplug its harness connector(s) and unscrew the threaded ring around its body.

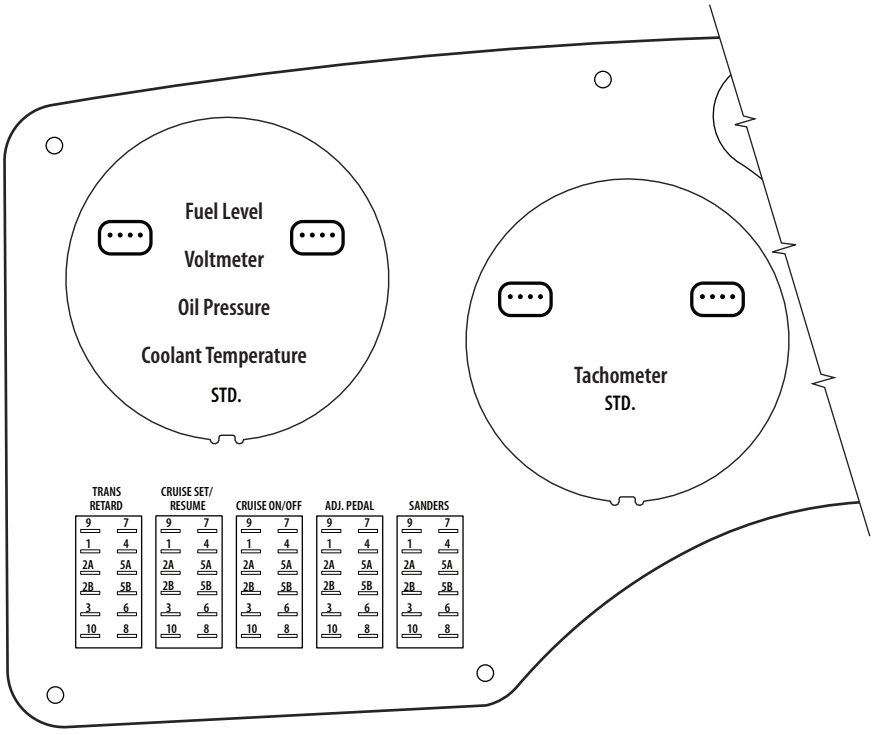
Testing a Gauge By Substitution

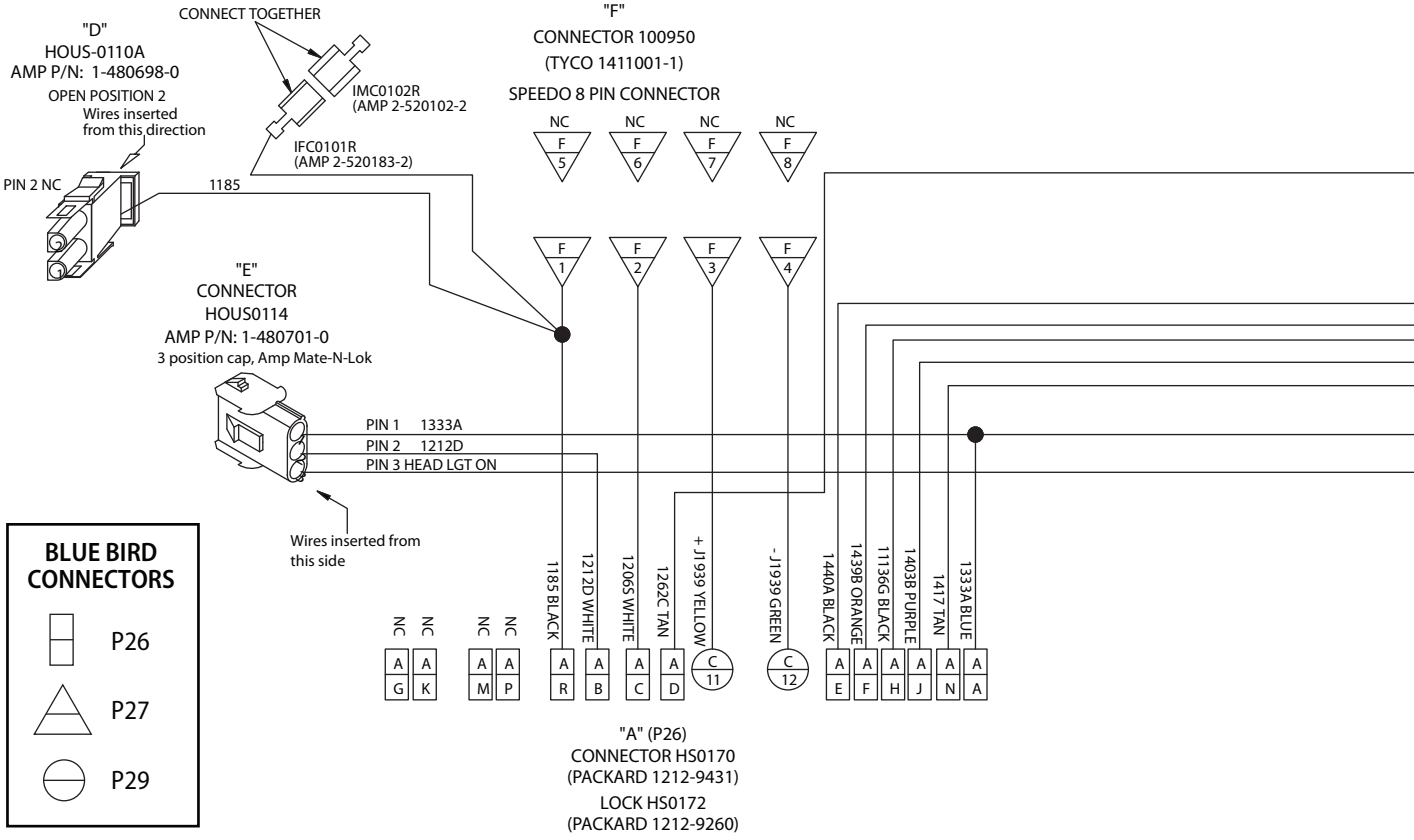
To help quickly determine if a suspected gauge is faulty, the harness connnector from an adjacent gauge can be temporarily substituted.

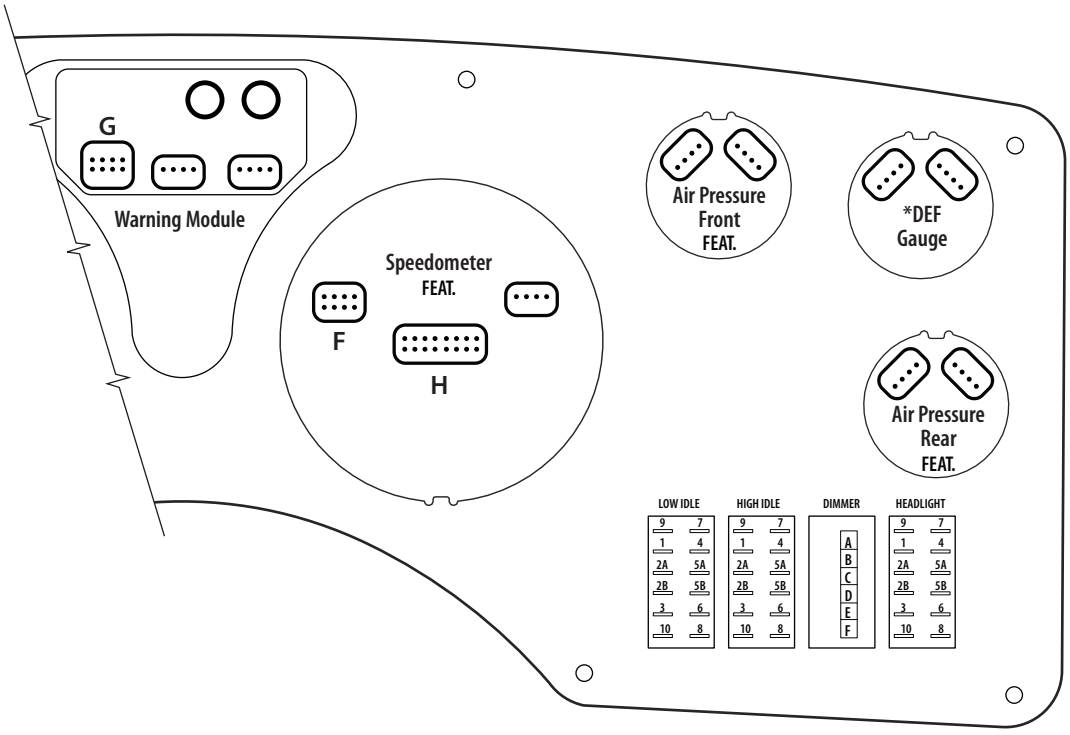
1. Label and remove the wiring harness from the gauge in question.
2. Label and remove the wiring harness from an adjacent gauge.
3. Plug the connector from the known "good" gauge into the suspect gauge.
4. Support the instrument cluster in a safe position.
5. Turn the ignition switch to the "ON" position. Start the engine if necessary.
6. Check whether the suspect gauge now indicates a value. If it does not, the gauge may be faulty. If the gauge indicator needle now indicates a reading, the original malfunction is probably not due to a faulty instrument panel harness. A gauge test can determine if the gauge itself needs to be replaced. There are other test and troubleshooting techniques available in Appendix 1. Refer to the manufacturer's service manual for instructions regarding signals originating from the engine ECM or transmission TCU. Electrical diagrams can also be found in this manual to aid in troubleshooting the entire circuit..

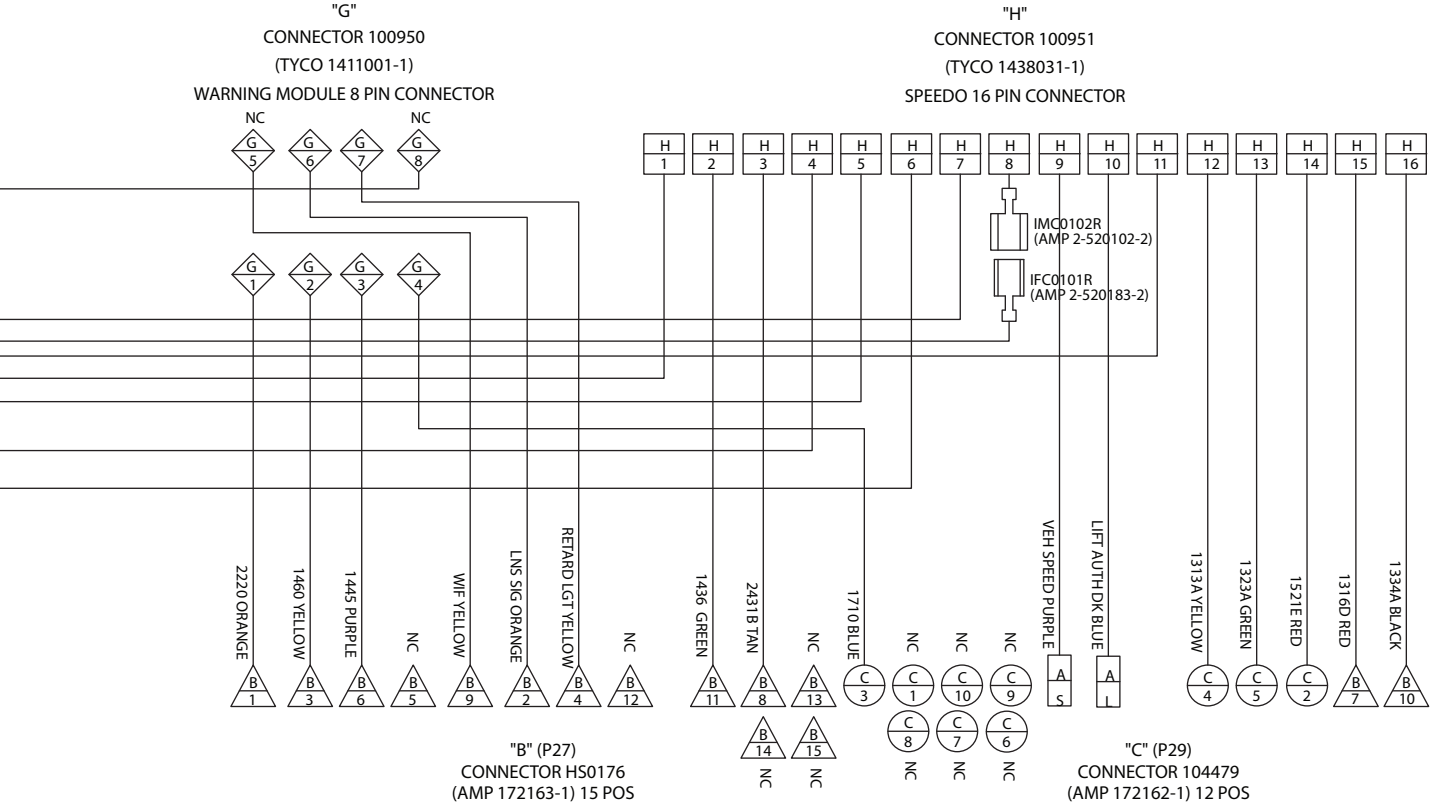
Note: **DEF Gauge on units equipped with ISB 2010 engines only.*



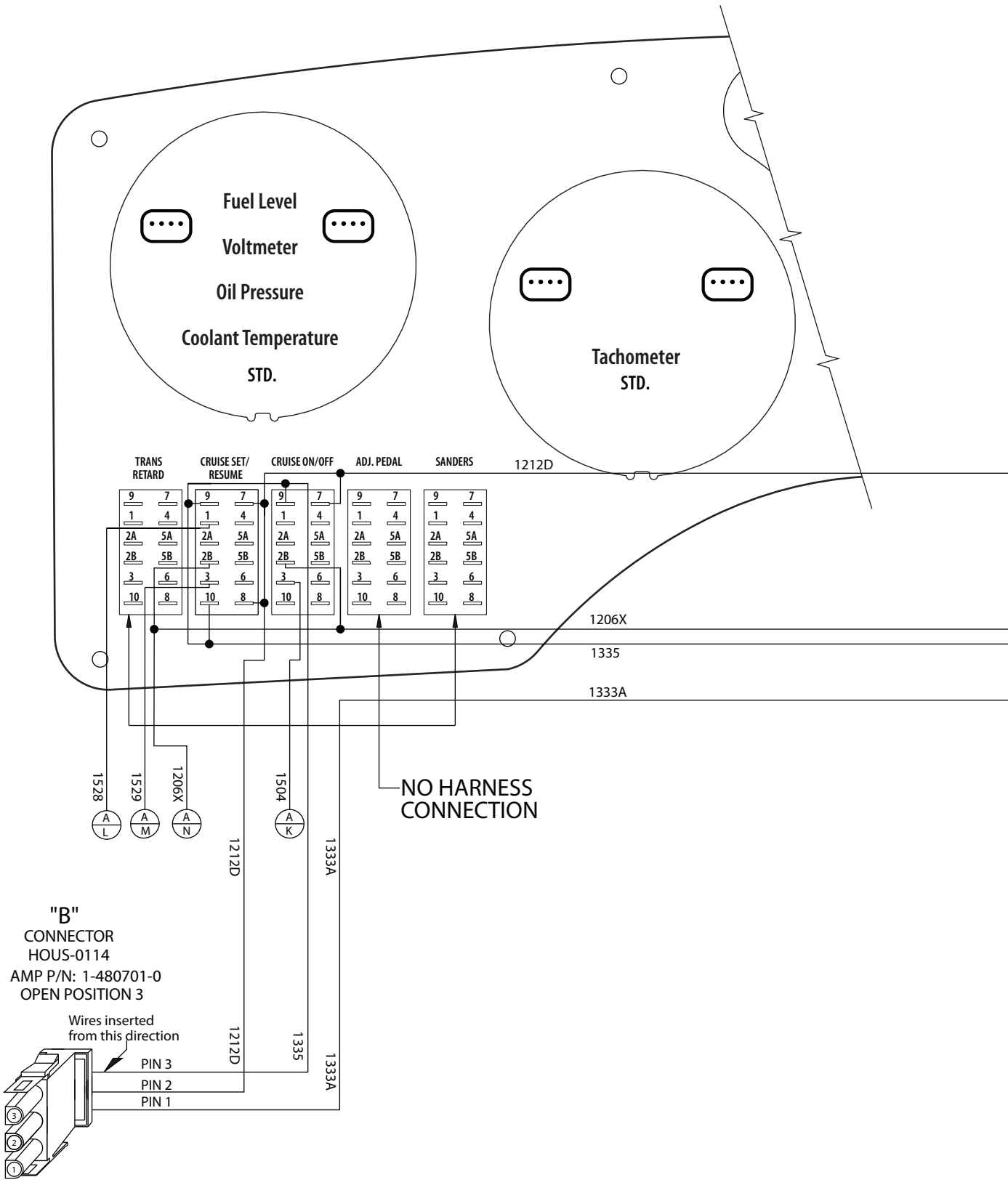

Fuel Level
Voltmeter
Oil Pressure
Coolant Temperature
STD.
Tachometer
STD.
TRANS RETARD
CRUISE SET/ RESUME
CRUISE ON/OFF
ADJ. PEDAL
SANDERS

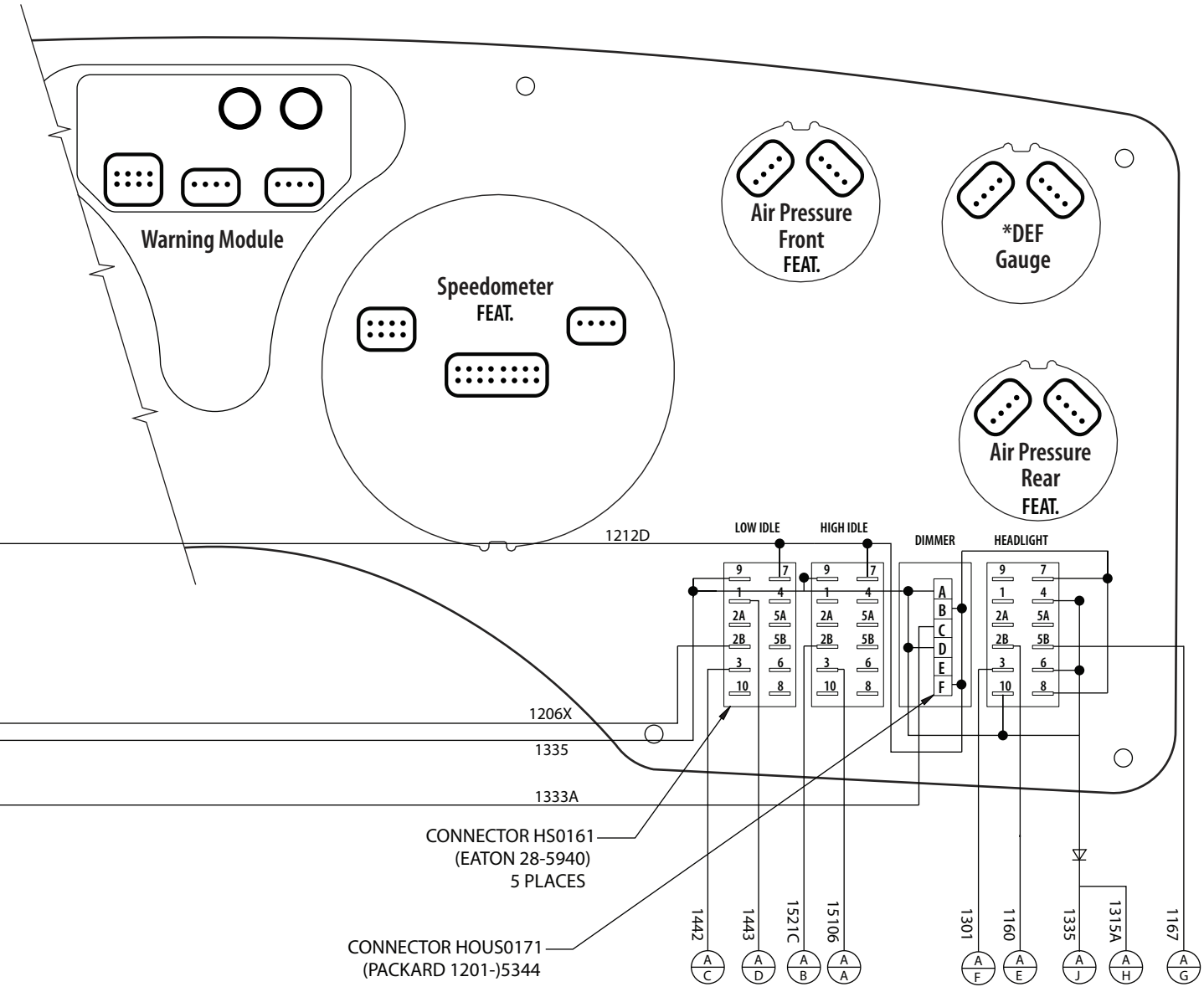

"D"
HOUS-0110A
AMP P/N: 1-480698-0
OPEN POSITION 2
Wires inserted from this direction
CONNECT TOGETHER
IMC0102R (AMP 2-520102-2
IFC0101R (AMP 2-520183-2)
PIN 2 NC
1185
"E"
CONNECTOR
HOUS0114
AMP P/N: 1-480701-0
3 position cap, Amp Mate-N-Lok
PIN 1 1333A
PIN 2 1212D
PIN 3 HEAD LGT ON
Wires inserted from this side
"F"
CONNECTOR 100950
(TYCO 1411001-1)
SPEEDO 8 PIN CONNECTOR
NC
1185 BLACK
1212D WHITE
1206S WHITE
1262C TAN
+ J1939 YELLOW
- J1939 GREEN
1440A BLACK
1439B ORANGE
11136G BLACK
1403B PURPLE
1417 TAN
1333A BLUE
"A" (P26)
CONNECTOR HS0170
(PACKARD 1212-9431)
LOCK HS0172
(PACKARD 1212-9260)
BLUE BIRD CONNECTORS
P26
P27
P29





Instrument Gauge, Schematic


Fuel Level
Voltmeter
Oil Pressure
Coolant Temperature
STD.
Tachometer
STD.
TRANS RETARD
CRUISE SET/ RESUME
CRUISE ON/OFF
ADJ. PEDAL
SANDERS
1212D
1206X
1335
1333A
1528
1529
1206X
1504
NO HARNESS CONNECTION
"B"
CONNECTOR
HOUS-0114
AMP P/N: 1-480701-0
OPEN POSITION 3
Wires inserted from this direction
PIN 3
PIN 2
PIN 1
1212D
1335
1333A



"A"
CONNECTOR HS0171
(PACKARD 1212-9427)
LOCK HS0172
(PACKARD 1212-9260)
(BLUE BIRD CONNECTOR P28)

Instrument Switch, Schematic

ACTIA®
52765 Bridger Court
Elkhart, IN 46514
USA

Phone: 574 264 2373

www.actia.com

Service Gauge Operation

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	By	Date		ACTIA Ref.	Revision
Written	David Troup	11/14/2003	**Service Gauge Operation**	**104426**	**A**
Reviewed					
Approved					
			© 2003 Any reproduction of this document whether total or partial without the written consent of ACTIA is forbidden.	Page 1	Format US Letter

104426 Rev A	Date: 12/03/03	*Page* 2 of 4

REVISION TRACKING SHEET

Rev	Modified	Date	Comment
0 A	D Troup	02-12-2003 11-20-2003	Original Draft Added units set; Released under part number

104426 Rev A	Date: 12/03/03	*Page* 3 of 4

1. Service Set Odometer Feature --

Warning -- Federal Law requires that the odometer accurately display the vehicle's actual mileage. It is the responsibility of the person installing the Master gauge to make sure the mileage programmed into the odometer correctly matches the vehicle's actual mileage.

The Service Set feature allows the season odometer to be set by the service technician installing a new master gauge into a vehicle. The odometer value is programmed using the front panel buttons and no other tools are necessary.

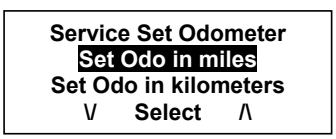
When the Master gauge is powered up the LCD will display the fact that this is a Service Set Gauge and the odometer must be set. **The Master gauge will function in a limited mode until the Odometer has been set.** Access to the set feature is controlled in the EEPROM and is secured using a four-byte code that prevents accidental access to this feature.

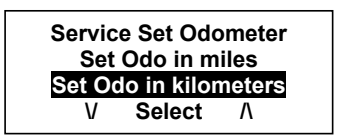
2. Limited Function

All gauge pointers will sit at zero position and not operate prior to setting the odometer while the LCD will only show the Service Set messages. All other parts of the system will operate. Warning icons located in the warning modules and in gauges will function normally and buzzer tones associated with the warnings will be allowed. Once set, the Service Set Gauge screen will not be seen again and the odometer value cannot be changed.

3. Setting the Units

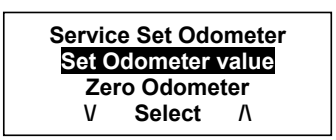
Prior to setting the odometer value the technician must indicate to the gauge whether English (miles) or metric (kilometers) units are being set. The gauge will default to the unit that was set when the gauge left the factory. To change, press the ***m*** or ***t*** button to scroll to the proper unit and press both buttons to select.

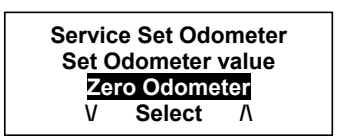




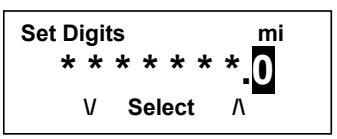
4. Setting the Odometer Value

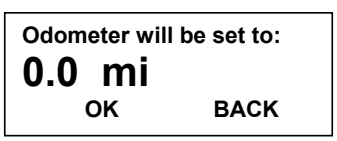
By using the ***m*** or ***t*** button to scroll you can highlight either Set Odometer Value or Zero Odometer.



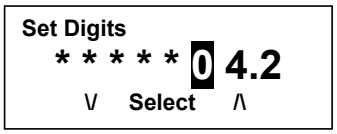


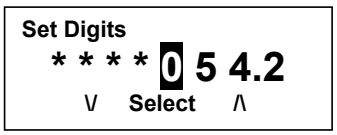
Selecting Set Odometer Value displays the Set Digits screen, while selecting Zero Odometer displays the confirmation screen.

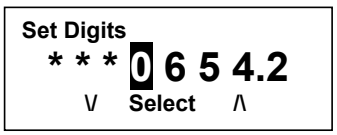




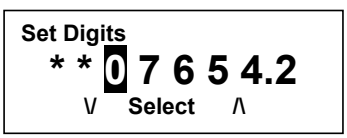
Each digit is set by using the ***m*** and ***t*** buttons to scroll forward and backward through the digits 0 – 9. Pressing ***m*** and ***t*** together stores the digit and displays the next digit to be set. The following screens show programming 7654.2 into the odometer.

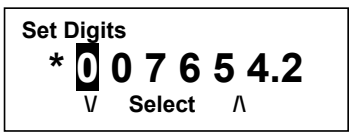


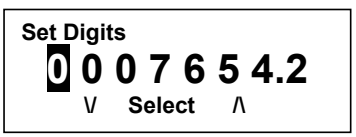




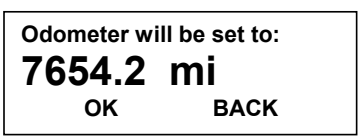
All digits must be set, but since pressing the ***m*** and ***t*** buttons together for select brings up the next digit as zero, you can quickly set the remaining digits to zero.







Once all digits have been set the confirmation screen will be displayed. Pressing ***m*** will accept the mileage while pressing ***t*** will take you back to the beginning Service Set Gauge screen to start over.



Doran Warning Light Monitor

The Doran Monitor™ is a current sensing device. If current is flowing through one of the bus lamp circuits, the monitor senses it and illuminates the corresponding monitor light emitting diode (LED). When a lamp burns out, current flow through the circuit stops and the corresponding LED on the monitor does not illuminate, indicating the outside lamp is not functioning. The Doran™ Monitor is located in the bulkhead over the windshield and slightly to the left of the driver.

Warning lights are such an essential safety feature, it is important to know when they are not working properly. This is the function of the Doran monitor. Its display is a schematic of the lights as they appear outside the bus. It continuously monitors the current in each lamp. If current is flowing through a particular bus lamp circuit (i.e., the light is on), the monitor senses this and lights the corresponding monitor bulb. If the bus lamp burns out, current ceases and the corresponding monitor bulb goes out, indicating a fault. Once the defective lamp is replaced, and the warning lights are working normally again, this also should be shown by the monitor.

The Doran monitor is a reliable, long-life device, but as with most electrical instruments, it can be overheated and damaged if an overload occurs in a bus light. Such overloads can exist if a bus light circuit becomes shorted, forcing current through a coil in the monitor that exceeds the coil's rated capacity. Short circuits can occur if improper connections are made during installations, bus repairs, etc. If the monitor has an optional thermistor overload protection, the tail light circuits are overload-protected. (Thermistors are located on the bottom of the component side of the printed circuit board.)

Doran Troubleshooting

CAUTION ***Do not attempt to check a light emitting diode (LED) with an ohmmeter. Some digital voltmeters (DVM) have a diode checking position, which is acceptable for testing LEDs. Any repair of the Doran Warning Light Monitor™ should be referred to a qualified technician.***

If the Doran Warning Light Monitor™ does not display any indicator LEDs:

- An overload situation may have created an open circuit: Check the system fuses.
- An overload (due to addition of extra lights or other loads to the circuit) or physical damage may have burned or broken a conductor on the printed circuit board: Remove the extra load and replace the damaged printed circuit board.
- Excessive vibration or abuse has resulted in a damaged monitor. Replace the printed circuit board.

If a particular LED on the Doran Warning Light Monitor™ does not display, but the bus running lights are operating properly:

- The coil is burned due to an overload. Replace the coil kit.
- A solder joint has weakened (a cold solder joint). Flow new solder on the connection.
- The reed switch has failed, the reed has broken, or the contacts have failed. Replace the reed switch kit.
- The printed circuit board is broken or burned. Replace the printed circuit board.
- There is an open in the LED circuit. Replace the LED.

If a monitor LED indicator is on, but the bus running light indicated is not operating, or the bus running light switch is in the off position and the monitor indicates the running lights are operating:

- Replace the coil and reed switch kit.

If neither the bus running lights nor the Doran Warning Light Monitor™ operates properly:

- The running light bulb may be burned out. Replace the light bulb.
- The overload thermistor has protected the circuit from overload. Remove the overload condition (a short; incorrect light bulb(s); Extra lights, etc.) (i.e., trailer lights, etc.)

Calibration

To self calibrate the monitor, ALL monitored lights must be in working order. For faster calibration, the operator may turn on as many exterior lights as possible at the start of the procedure. The operator will be required to activate these lights during the calibration procedure. Operator may begin with the tail/head lights on, hazard lights (for the turn signals), and the amber warning lights flashing (door closed).

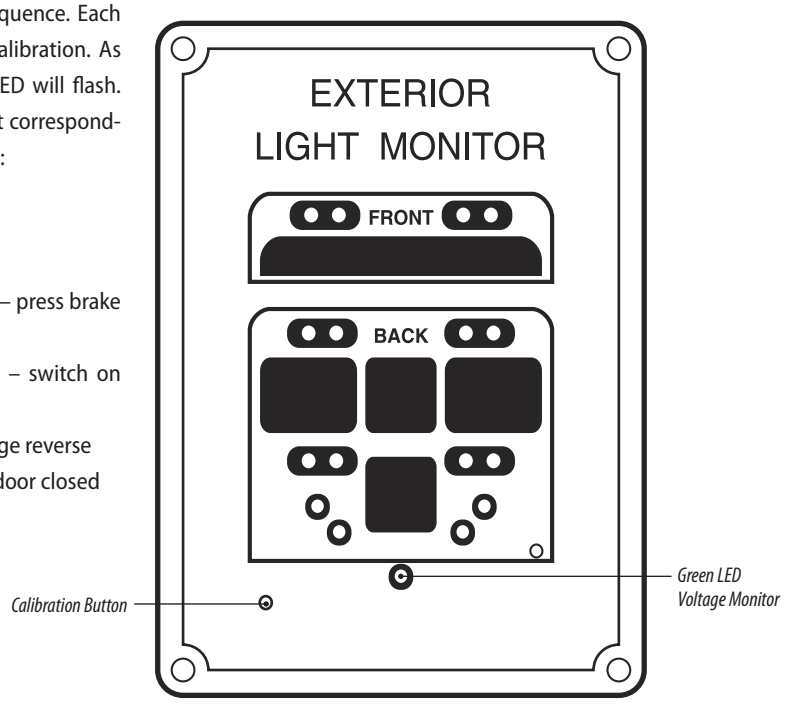
1. Turn on ignition and start engine – Engine is running to assure proper voltage for operation and calibration. The GREEN LED voltage indicator at the bottom center of the monitor MUST BE ILLUMINATED indicating the voltage is within limits for proper operation. Before beginning calibration, allow time for the voltage to stabilize to its normal running voltage. After cranking the engine the battery voltage may be lower than normal. Allow time for the battery to recharge.

2. When the ignition is turned on, all LED's on monitor will be enabled for a few seconds to verify that all LED's are working.

3. To enter the calibration mode, press and hold the calibrate button through the face plate hole for longer than two (2) seconds. This button/hole may be found located at the bottom left corner of the bus image on the monitor face plate. The first light to calibrate will begin flashing when the unit enters calibration mode. You may use an object such as an allen wrench or paper clip to activate the switch.

4. The unit will begin calibrating each light in a sequence. Each light tested must be active at the time of the calibration. As each light is calibrated, the matching monitor LED will flash. Operator shall activate (if not active) the bus light corresponding to the flashing LED. The sequence is as follows:

   a. Left turn signal – switch on
   b. Right turn signal – switch on
   c. Stop lights (left, then right side 7" will flash) – press brake pedal
   d. Tail light (left, then right side 4" will flash) – switch on (brakes off)
   e. Backup lights – press brake/clutch and engage reverse
   f. Each Amber warning light – switch on with door closed
   g. Each Red warning light – open door



5. Calibrated lights are indicated by the corresponding LED staying illuminated on the monitor. The unit continues to loop through the sequence flashing the un-calibrated lights until all lights are calibrated.

6. When all LED's are illuminated, turn off ignition to complete the calibration.

Heater / Wiper Control Panel Illumination

The heater and windshield wiper controls are illuminated by a thin electro luminescent (EL) layer that is laminated to the back of the heater control panel face plate and the windshield wiper control panel face plate.

The EL Panels are illuminated when 110 volts AC is applied to the electrical circuits connected to each panel. The electro luminescent layer provides even illumination across its entire surface area. The translucent areas in the control panel face plate allows light to illuminate the details on its front surface making the panel visible during low light conditions.

CAUTION ***The EL Panel inverter produces 110 volts AC output to illuminate the panel. Avoid contact with unprotected inverter output circuits, inverter output terminals and the heater/wiper EL Panel circuits while the headlights/ park lights are activated. Use caution while troubleshooting the heater/wiper control panel illumination circuits to avoid electrical shock.***

The AC voltage required to activate the electro luminescent layer is generated by an electrical inverter that supplies the heater and wiper control panels. When 12 volts DC is applied to the inverters input circuits (green connector) the inverter generates an output of 110 volts AC on its output circuits (red connector), illuminating the heater/wiper control panels. The electrical load on the inverter is proportional to the specific square inchers of surface area being illuminated by both EL Panels.

A failure of the heater or wiper EL Panel to illuminate could be due to low or no supply voltage to the inverter, a failed inverter, a failed EL Panel, or the electrical circuits connecting the components. A simple process of elimination by testing the EL Panel electrical system with a volt meter should identify the failed component.

Use the following test procedures in the event either of the control panels fail to illuminate when the headlights or park lights are on and the switch panel dimmer located on the left switch panel is in the full bright position. Reference the "Heater & Defroster, Kysor" electrical schematic in the Chassis Electrical chapter of this manual.

1. Remove the Wiper and Heater control EL Panels by removing the screws securing them.

2. To determine EL Panel failure.

   a. Disconnect the Wiper EL Panel electrical connector located behind the Wiper control panel. Turn on the headlights and move the switch panel dimmer to the bright position.

   b. If the Heater EL Panel illuminates the wiper EL Panel has failed and should be replaced.

   c. If the Heater EL Panel does not illuminate turn off the headlights and reconnect the Wiper EL Panel.

   d. Disconnect the Heater EL Panel electrical connector located behind the Heater control panel. Turn on the headlights and move the switch panel dimmer to the bright position.

   e. If the Wiper EL Panel illuminates the Heater EL Panel has failed and should be replaced.

   f. If the wiper EL Panel does not illuminate turn off the headlights and continue testing.

2. Disconnect the green inverter input connector (located behind the heater control panel).

3. Turn on the headlights and move the switch panel dimmer to the bright position.

4. Measure voltage between the two power supply terminals coming from the bus electrical system. (voltage should be 12 volts DC).

5. If voltage is low or no voltage is measured, back track the supply circuit and make necessary repairs. If voltage is OK turn the headlights off, reconnect the inverter input connector and continue testing.

6. Disconnect the red inverter output connector.

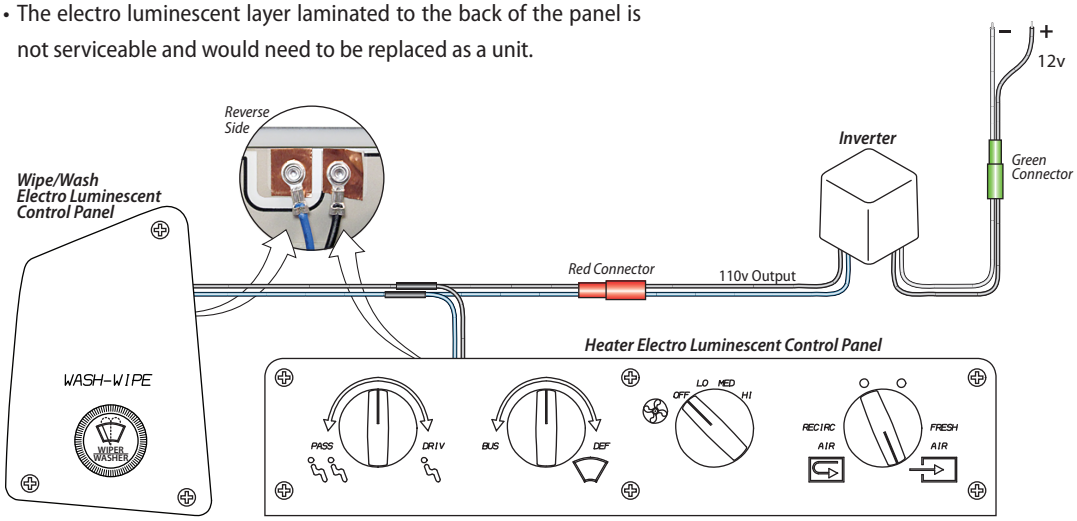
7. Turn on the headlights and move the switch panel dimmer to the bright position.

8. Measure voltage between the two output terminals coming from the inverter. Make sure to set your voltmeter for AC voltage. Voltage should be minimum of 110 volts AC.

   - If voltage is low or no voltage is measured, the inverter has failed and needs to be replaced. *Note: Repeat inverter failures may be caused by shorted circuits or a pinched EL Panel*.

   - If a minimum of 110 volts is measured at the inverter output, the electrical circuit connecting the inverter to the EL Panel or the EL Panel has failed.

   - The electro luminescent layer laminated to the back of the panel is not serviceable and would need to be replaced as a unit.

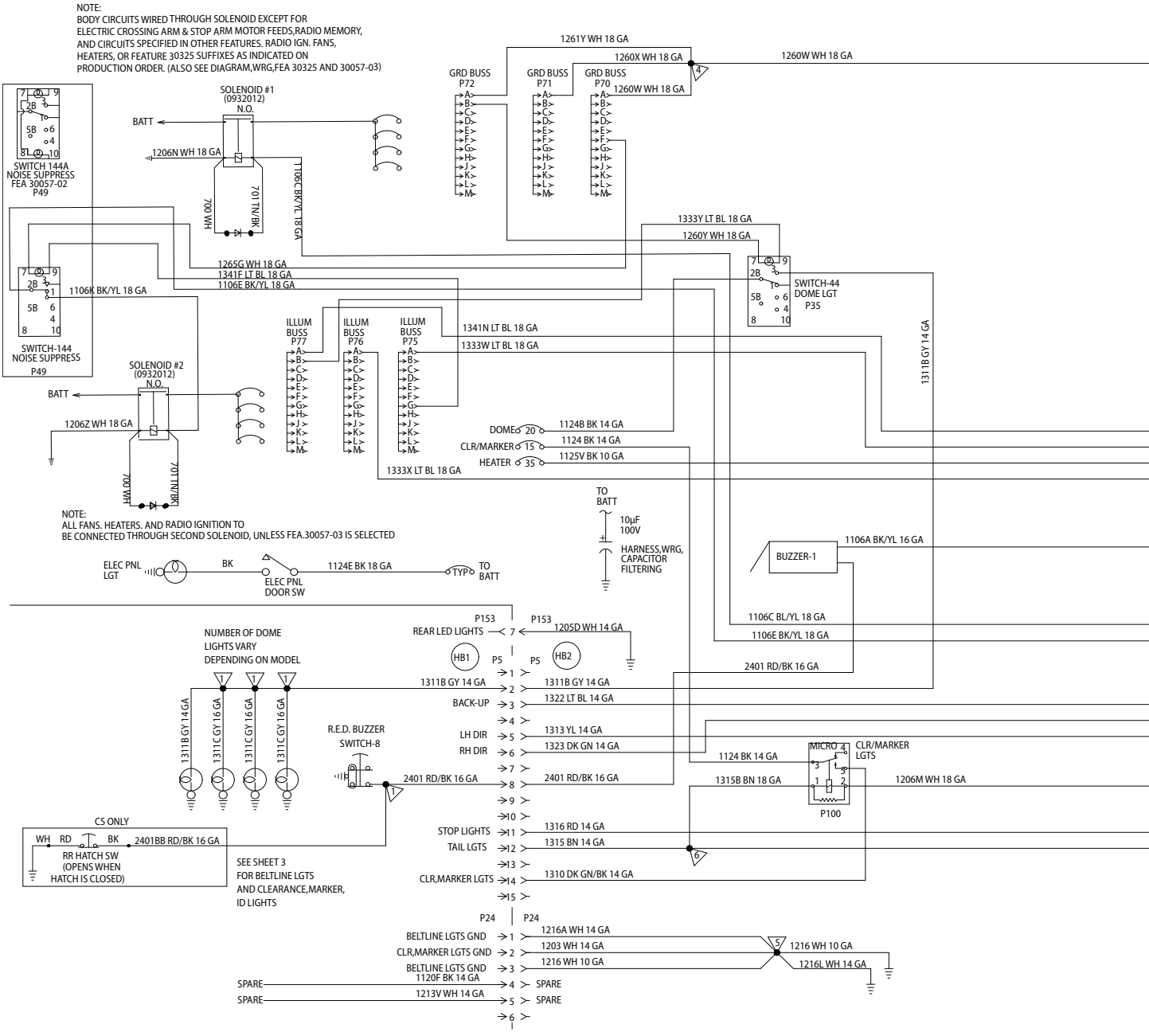


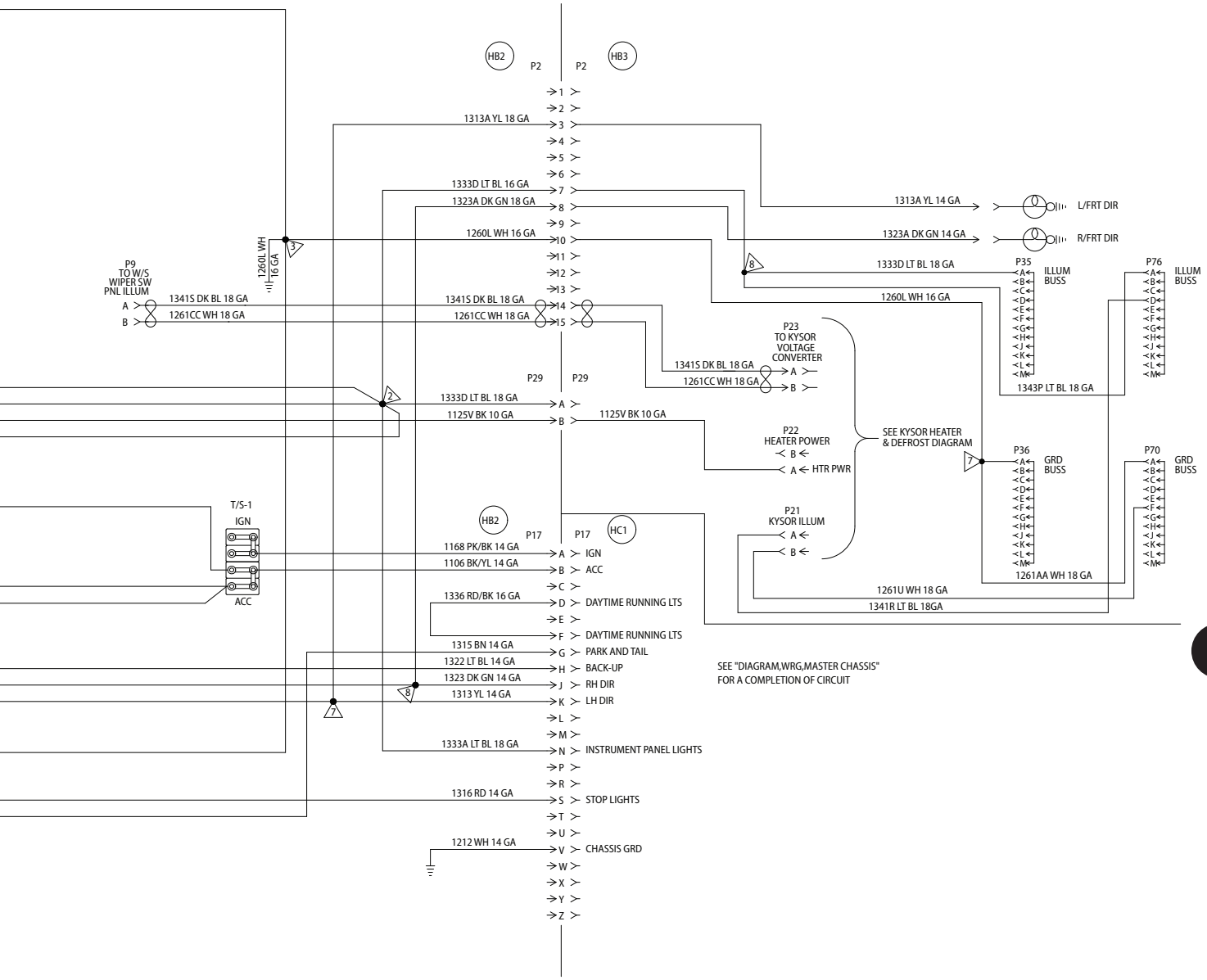
Body Wiring Schematics

Many customer selected options which affect wiring are available for the All American. For your convenince when you are limited to the print version of this manual, the following pages contain the standard equipment wiring diagrams representative of circuits common to most All American bodies. However, the Tech Reference DVD contains a much more comprehensive set of schematics which includes many additional diagrams pertaining to specific equipment installations.

When using the DVD, click the Electrical Schematics Body link in the Bookmarks pane. The first page of the Body Electrical Schematics group contains instructions on how to use the linking and navigation features.

The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged as occurs with bitmap formats. This also means that you may print the drawing to your own office or desktop printer while maintaining legibility even at significant reductions.

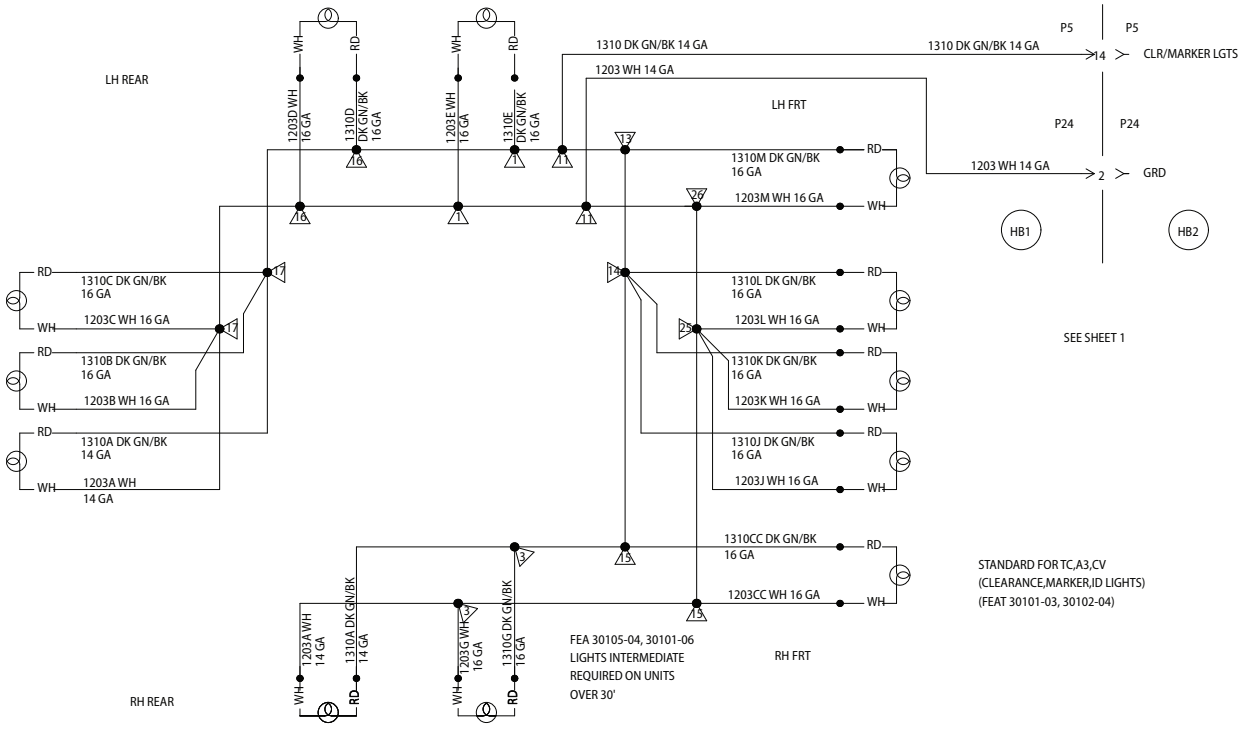

NOTE:
BODY CIRCUITS WIRED THROUGH SOLENOID EXCEPT FOR
ELECTRIC CROSSING ARM & STOP ARM MOTOR FEEDS,RADIO MEMORY,
AND CIRCUITS SPECIFIED IN OTHER FEATURES. RADIO IGN. FANS,
HEATERS, OR FEATURE 30325 SUFFIXES AS INDICATED ON
PRODUCTION ORDER. (ALSO SEE DIAGRAM,WRG,FEA 30325 AND 30057-03)
SWITCH 144A
NOISE SUPPRESS
FEA 30057-02
P49
SOLENOID #1
(0932012)
N.O.
BATT
1206N WH 18 GA
700 WH
701 TN/BK
1106C BK/YL 18 GA
1261Y WH 18 GA
1260X WH 18 GA
1260W WH 18 GA
GRD BUSS
P72
GRD BUSS
P71
GRD BUSS
P70
1333Y LT BL 18 GA
1260Y WH 18 GA
1265G WH 18 GA
1341F LT BL 18 GA
1106E BK/YL 18 GA
1106K BK/YL 18 GA
SWITCH-144
NOISE SUPPRESS
P49
SWITCH-44
DOME LGT
P35
ILLUM
BUSS
P77
ILLUM
BUSS
P76
ILLUM
BUSS
P75
1341N LT BL 18 GA
1333W LT BL 18 GA
1311B GY 14 GA
SOLENOID #2
(0932012)
N.O.
BATT
1206Z WH 18 GA
700 WH
701 TN/BK
DOME
20
1124B BK 14 GA
CLR/MARKER
15
1124 BK 14 GA
HEATER
35
1125V BK 10 GA
1333X LT BL 18 GA
TO
BATT
10µF
100V
HARNESS,WRG,
CAPACITOR
FILTERING
NOTE:
ALL FANS. HEATERS. AND RADIO IGNITION TO
BE CONNECTED THROUGH SECOND SOLENOID, UNLESS FEA.30057-03 IS SELECTED
ELEC PNL
LGT
BK
1124E BK 18 GA
TYP
TO
BATT
ELEC PNL
DOOR SW
BUZZER-1
1106A BK/YL 16 GA
1106C BL/YL 18 GA
1106E BK/YL 18 GA
2401 RD/BK 16 GA
P153
REAR LED LIGHTS
P153
1205D WH 14 GA
HB1
P5
P5
HB2
NUMBER OF DOME
LIGHTS VARY
DEPENDING ON MODEL
1311B GY 14 GA
1311C GY 16 GA
1311C GY 16 GA
1311C GY 16 GA
1311B GY 14 GA
1311B GY 14 GA
BACK-UP
1322 LT BL 14 GA
LH DIR
1313 YL 14 GA
RH DIR
1323 DK GN 14 GA
R.E.D. BUZZER
SWITCH-8
2401 RD/BK 16 GA
2401 RD/BK 16 GA
1124 BK 14 GA
1315B BN 18 GA
MICRO
CLR/MARKER
LGTS
1206M WH 18 GA
P100
CS ONLY
WH
RD
BK
2401BB RD/BK 16 GA
RR HATCH SW
(OPENS WHEN
HATCH IS CLOSED)
STOP LIGHTS
1316 RD 14 GA
TAIL LGTS
1315 BN 14 GA
CLR,MARKER LGTS
1310 DK GN/BK 14 GA
SEE SHEET 3
FOR BELTLINE LGTS
AND CLEARANCE,MARKER,
ID LIGHTS
P24
P24
BELTLINE LGTS GND
1216A WH 14 GA
CLR,MARKER LGTS GND
1203 WH 14 GA
1216 WH 10 GA
1216L WH 14 GA
BELTLINE LGTS GND
1120F BK 14 GA
1216 WH 10 GA
SPARE
SPARE
1213V WH 14 GA
SPARE
SPARE

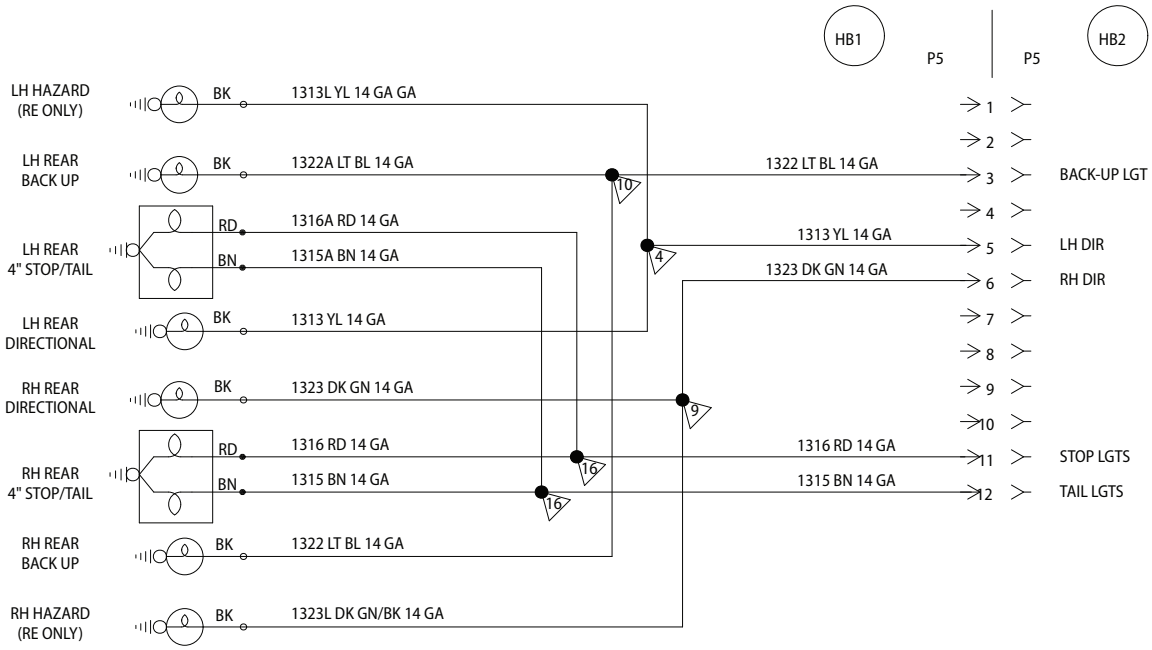


Standard Equipment, A3

0027476K

SHEET 1 of 3


LH REAR
RH REAR
LH FRT
RH FRT
1203D WH 16 GA
1310D DK GN/BK 16 GA
1203E WH 16 GA
1310E DK GN/BK 16 GA
1310 DK GN/BK 14 GA
1203 WH 14 GA
1310M DK GN/BK 16 GA
1203M WH 16 GA
1310C DK GN/BK 16 GA
1203C WH 16 GA
1310B DK GN/BK 16 GA
1203B WH 16 GA
1310A DK GN/BK 14 GA
1203A WH 14 GA
1310L DK GN/BK 16 GA
1203L WH 16 GA
1310K DK GN/BK 16 GA
1203K WH 16 GA
1310J DK GN/BK 16 GA
1203J WH 16 GA
1310CC DK GN/BK 16 GA
1203CC WH 16 GA
1203A WH 14 GA
1310A DK GN/BK 14 GA
1203G WH 16 GA
1310G DK GN/BK 16 GA
P5
CLR/MARKER LGTS
P24
GRD
HB1
HB2
SEE SHEET 1
STANDARD FOR TC,A3,CV
(CLEARANCE,MARKER,ID LIGHTS)
(FEAT 30101-03, 30102-04)
FEA 30105-04, 30101-06
LIGHTS INTERMEDIATE
REQUIRED ON UNITS
OVER 30'



STANDARD FOR TC,C1FE,A3, & CV
(BELTLINE LGTS)

SEE SHEET 1

Charging System

The charging system provides electrical current for the lights, radio, heater blower and the engine's electrical systems. It also maintains the batteries in a charged state, recharging them as necessary to provide cranking power.

The charging system has three main components, or component areas: the alternator, the voltage regulator, and the battery.

The alternator is driven by a belt from the engine crankshaft and produces the electrical power to operate the systems on the bus. It also recharges the battery.

The voltage regulator acts as a "control valve" for the alternator output. It senses the current load and maintains a constant voltage in the charging system, independent of the current load, up to its rated output. The alternator on the Blue Bird All American has a "built in" voltage regulator. It is excited (started) by the ignition system.

The battery is the reservoir of chemical electrical power. Its primary purpose is to crank the engine. It also supplies power to the accessories for a short time when the demand is too high for the alternator alone (i.e., while the bus is at idle). Another key role of the battery is to act as a filter for the charging system by providing clean "electronic power" for the electronic control systems; ECU, ECM, TCM, and gauges.

Maintenance

Clean the alternator and all connection points. Dirt buildup restricting air flow through to the alternator will cause excessive heat and premature failure. Corrosion at any connecting point will produce resistance to current flow, heat and diminished power for the accessories.

Ensure that all the components in the charging system are mounted securely. Check the torque at all mounting bolts — both the bolts that hold the alternator in the mounting bracket and the bolts that secure the mounting brackets to the engine. The torque value for mounting bolts at the engine and at the alternator should be 60 – 70 ft lb.

Blue Bird All American buses are equipped with an automatic belt tensioner. Ensure that all the grooves fit properly into the pulleys in the correct path. The drive belt should be inspected every 11,000 miles (17,700 km), 250 hours of service life, or every 3 months; whichever occurs first.

Also check:

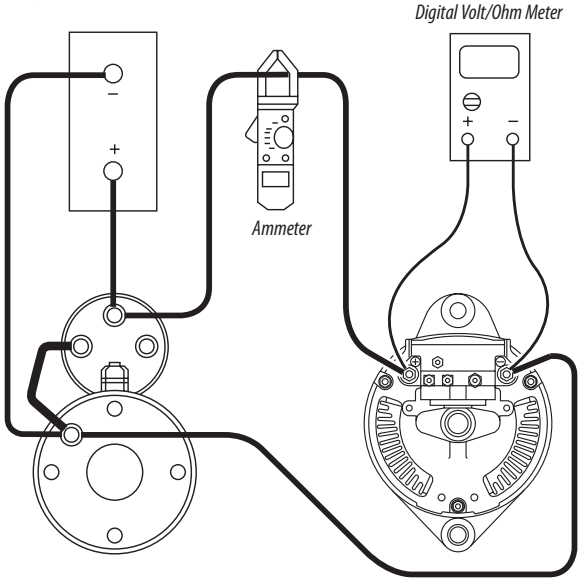
- Battery voltage
- Alternator output
- Starter current draw

Troubleshooting

Timely preventive maintenance of the charging system should keep it running smoothly. However, when a problem occurs, effective troubleshooting procedures will help locate and correct the problem quickly and economically.

WARNING ***Batteries emit an explosive gas. Never smoke while working on the charging system. Batteries can explode from a spark. Always remove the negative battery cable at the battery post before removing any other wires in the charging system. Be careful not to short the system while you are working on it. Do not wear jewelry.***

Before you begin to analyze the charging system, it is necessary that you ensure the battery is properly tested and charged to at least 75% of their rated capacity. Failure to confirm the condition of the battery will make the results of any diagnostic testing unreliable. Refer to the battery manufacturer's publications on battery maintenance and testing.



Alternator Performance Test

1. Connect a digital volt/ohmmeter (VOM) to the output terminals of the alternator.

   CAUTION ***Ensure that the test leads are connected properly. Observe the polarity and make secure connections.***

2. Connect an ammeter to the positive terminal of the alternator. Observe that the clamp on the ammeter is located at least 6 inches (15 cm) from the alternator to lessen the possibility of faulty readings due to spurious emissions.

3. Verify that the voltage output from the alternator is between 13.8 and 14.2 volts with the engine at operating RPM (1700 RPM minimum) and not idle.

4. Ensure that all "loads" are in the off position. The reading on the ammeter should be less than 20 amps.

   - If the amp reading is higher than 20 amps, ensure all accessories are turned off.

   - Ensure the battery is charged to at least 75% of their rated capacity.

5. Record the voltage. If the voltage is not within the specified range or the amperage is not within the specified range, the alternator is defective.

6. If the alternator is determined to be defective, repair or replace it in accordance with the instructions below. See Alternator Removal.

7. If the alternator is determined to be functioning properly, proceed as follows:

8. Continue to operate the engine at about 1700 RPM, and with the test equipment set up as illustrated.

9. Turn on vehicle loads (accessories) until the ammeter displays amps, 75% of the rated capacity of the alternator. Record the voltage at this point.

10. Compare the voltage reading with the voltage reading observed in Step 3 above.

11. If the alternator voltage drops more than .5 (1/2) volt, the alternator is defective.

An alternate method of checking the alternator under load is to use a carbon pile load. Connect the carbon pile across the battery and adjust it until the ammeter reads 75% of the alternator rated capacity. Record the voltage at this point, shut off the engine, and compare the readings.

Alternator Cable Tests

To test the positive alternator cable:

1. Clamp the ammeter on the positive cable at least 6 inches (15 cm) from the alternator. See Figure 2.

2. Connect the negative lead of the VOM to the positive post of the alternator.

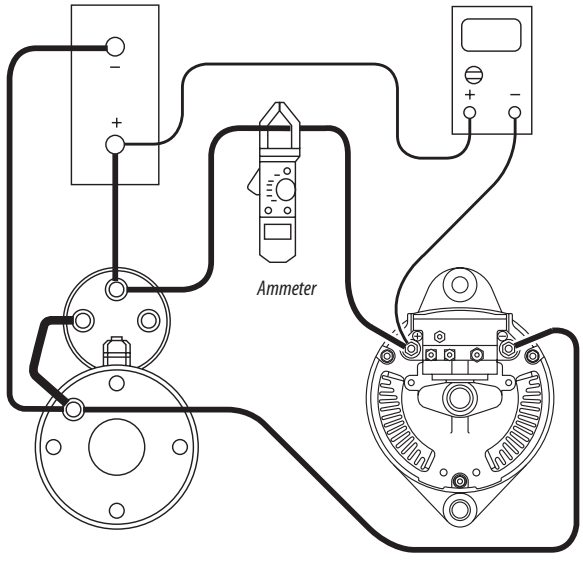
3. Connect the positive lead of the VOM to the positive battery post.

4. Start the engine and let it run at about 1700 RPM.

5. Turn on accessories until the ammeter reads amps, which is 75% of the rated alternator capacity, Use a carbon pile if necessary to achieve the load.

6. Record the voltage reading on the VOM.

Digital Volt/Ohm Meter



7. If the VOM reads more than -.25 volts, there is a problem with the positive cable.

   • Check and clean all the connections and the condition of all the cables/wires in the circuit.

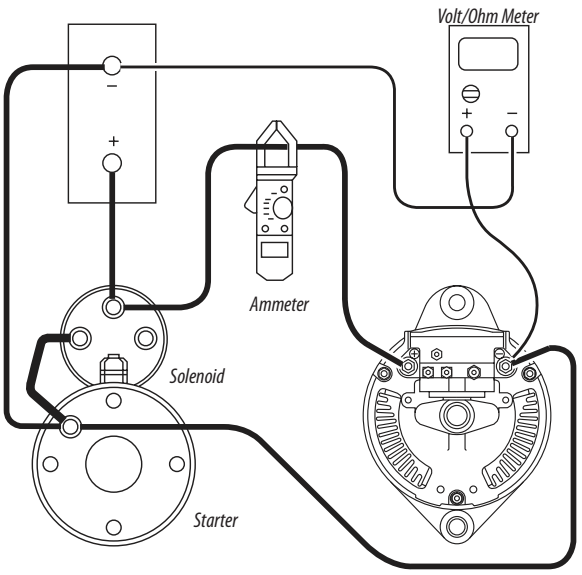
   • Re-test the circuit.

8. If the reading is less than -.25 volts, the cable and connections are good.

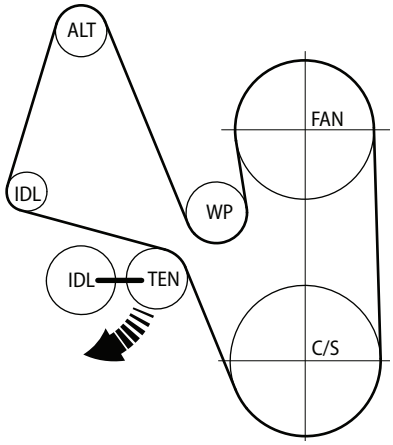
9. Connect the negative lead of the VOM to the negative terminal of the battery.

10. Connect the positive lead of the VOM to the negative terminal of the alternator.

11. Repeat Steps 4 through 8 for the negative cable.

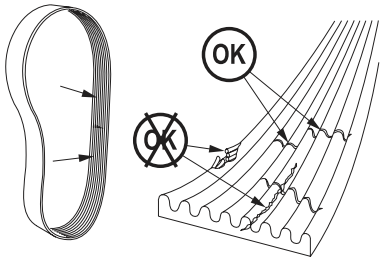


Alternator Removal



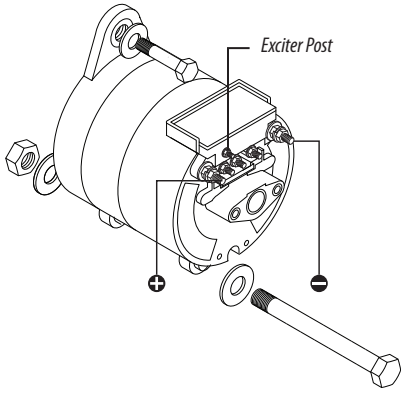
WARNING ***Always disconnect the negative (-) cable from the battery terminal first to avoid arcing, which could ignite explosive battery gases.***

1. Park the bus on a smooth, flat surface.
2. Chock the wheels in both directions.
3. Ensure the engine is not running, the ignition switch is in the "OFF" position and the key is removed.
4. Disconnect the negative (ground) cable from the battery post.
5. Lift the automatic belt tensioner to remove the drive belt from the alternator.
6. Remove the drive belt.
7. Inspect the drive belt; discard it if any signs of wear are present.



A few minor cracks across the belt are acceptable. Longitudinal cracks are NOT acceptable. Replace the drive belt when any crack is observed to be running lengthwise or with the belt, or when the belt appears frayed.

WARNING ***Always disconnect the negative (-) battery cable at the battery before removing any wiring from the alternator.***



8. Remove the negative (-) cable from the alternator.
9. Remove the positive (+) cable from the alternator.
10. Remove the ignition wire from the exciter post.
11. Remove the locknut and washer from the bottom mounting bolt. Remove the bolt from alternator mounting bracket.
13. Remove the bolt and split ring lock washer from the top of the alternator.
14. Remove the alternator.

Alternator Reinstallation

Installation of the alternator is accomplished in the reverse order of the removal instructions above.

1. Position the alternator under the top holding bracket.
2. Install the washer (7) on the bolt (8). See Figure 7.
3. Install the bolt (8) and washer (7) assembly finger tight.
4. Install lock washer (5) on the through bolt (6).
5. Install the through bolt/washer assembly through the holding bracket and the alternator mounting holes.
6. Install the washer (5) onto the through bolt.
7. Install the locknut (4) on the through bolt.
8. Torque bolts (6 and 8) to 60 – 70 ft lb.
9. Install the ignition exciter wire on the IGN post (3). Tighten carefully to avoid breaking or stripping the stud. See Figure 6.
10. Install the positive cable (2) on the B+ post. Carefully tighten to avoid breaking or stripping the stud.
11. Install the negative cable (1) on the B - post. Carefully tighten to avoid breaking or stripping the stud.
12. Using a square drive tool, position the automatic tensioner so that the drive belt can be installed. Inspect the drive belt carefully. Replace the belt if any signs of wear are present.
13. Install the drive belt. Ensure that the grooves in the belt fit into the proper places on all the pulleys.

Automatic Belt Tensioner

The automatic tensioner is spring loaded to provide the proper tension for the drive belt.

The automatic tensioner should travel at least 71°, and the torque to move the tensioner 25° from the "at rest" position must be 9 – 11 ft lb (12.4 – 15.8 Nm). Inspect the belt tensioner for any unusual noise, excessive looseness and shaking at the bearings.

Automatic Tensioner Removal

1. Remove the drive belt in accordance with the instruc-tions above.

2. Remove the capscrew (1) from the automatic ten-sioner. See Figure 8.

To install a new automatic tensioner, reverse the removal instructions. Torque the capscrew (1) to 28 – 42 ft lb (38 – 56 Nm).

Starter

There are 5 main components or component areas in the starting system: the ignition switch, a neutral safety switch, the starter solenoid, the starter motor and the batteries.

When the key is turned to the start position, electrical current flows to the starter solenoid from the batteries. The flow is interrupted if the transmission shift lever is not in the neutral position or if the neutral sensor switch is defective.

The starter solenoid is an electromagnetic switch mounted on the starter motor. When electric current energizes coils inside the solenoid, a magnetic field is induced which pulls a plunger. At one end of this plunger is a lever. The lever is connected to the starter drive pinion of the starter motor. The plunger also connects the electrical power from the batteries to the starter motor as the drive pinion engages the flywheel ring gear.

The starter motor is a relatively small electric motor, but it can deliver large amounts of torque for a short time.

When the operator releases the ignition switch it returns to the run position. The solenoid is disconnected from the batteries and the magnetic field collapses. This allows the spring in the solenoid to move the plunger in the opposite direction, disengaging the drive pinion from the flywheel and removing electrical current from the starter motor.

The Blue Bird All American has a 12-volt electrical system.

Preventative Maintenance

There are two preventative maintenance procedures that can greatly enhance the efficiency of the starting system. These two steps are also the first two steps taken when troubleshooting a malfunctioning starting system.

- An engine that needs a tune up will be difficult to crank; over cranking will lead to starter motor failure.
- Poor connections due to road dirt, grease, corrosion, loose connectors, or broken insulation at any connecting point rob the starting system of electrical power and cause it to over-crank.

Troubleshooting

Before beginning to troubleshoot the starting system, ensure the batteries are properly maintained and charged to at least 75% of their rated capacity. A drained battery will cause any further diagnostic tests to be inaccurate. Common causes of starting system malfunction include:

1. A battery that is low, poorly charged, or defective places high demands on the starting system; voltage at the battery should be 12.5 volts or greater to crank the engine. If the batteries aren't adequately charging, a problem in the charging system. Refer to the Alternator section of this Service Manual for information on the charging system.

2. A starter motor can be damaged by heat that is generated by excessive cranking. The starter should never be engaged for more than 30 seconds. It must "rest" (cool off) a minimum of 2 minutes between starting attempts.

3. Loose, dirty, or corroded connections in the starting system rob the system of the power needed to turn the engine. The case of the starter motor is the ground or "return" connection for the starter motor and solenoid.

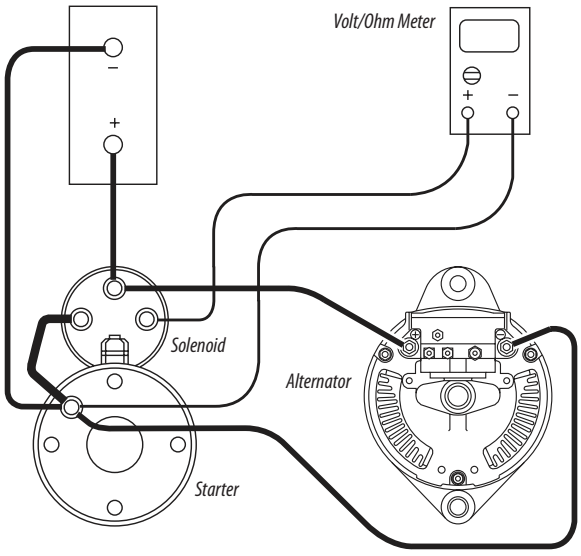
4. A loose starter motor will allow vibration that can damage the motor. In addition, the ring gear could be damaged.

5. Improper or excessive use of starting fluid will cause extra stress on the starting system.

6. A defective solenoid will fail to engage the starter drive pinion of the starter motor. A failed pull-in coil will cause the plunger to fail to pull in. A failed hold-in coil may cause the starter to fail to stay engaged, or may fail to switch the starter motor on. If the solinoid is suspect, test the wiring of the solenoid circuit before replacing the solenoid.

Ignition/Run Test

Begin by determining whether the problem is with the ignition switch or the pilot relay, and their associated wiring; or if it is in the solenoid and/or starting motor. To begin with the ignition switch:



1. Connect the positive lead of a VOM to the ignition switch terminal on the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, record the voltage displayed on the VOM. Observe the following:

   - No voltage
   - Low voltage
   - Normal voltage with slow cranking
   - Normal voltage with no cranking at all.

4. Connect a remote start switch to the positive battery post.

5. Connect the other end of the remote start switch to the ignition post of the solenoid.

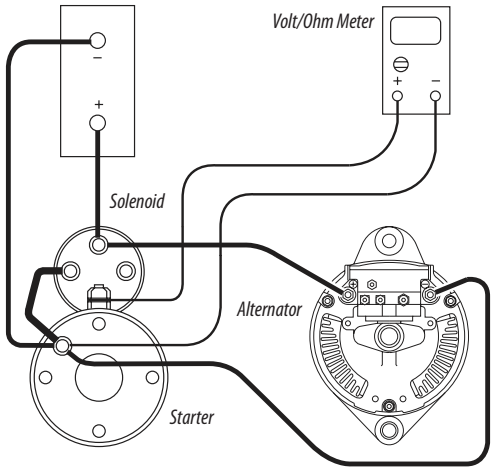
6. Attempt to crank the engine with the remote switch. Record the voltage displayed on the VOM. If there is less than 1 volt difference from the previous reading, the ignition switch is okay. If there is more than 1 volt difference, the switch is defective.

7. With the VOM negative lead connected to the chassis ground, move through the switch system one connection at a time. If your first voltage test has revealed low voltage, the starter motor may be shorted.

8. If the first voltage test indicated normal voltage, but there is slow cranking or no cranking at all, a problem with the batteries, battery cables, or a damaged starter motor is indicated.

Low Voltage Test

There are various reasons for low voltage but the troubleshooting methods are the same. If the solenoid clicks, it means that either current is flowing through the solenoid contacts but not through the main contacts; or that the current through the main contacts is insufficient due to low batteries.

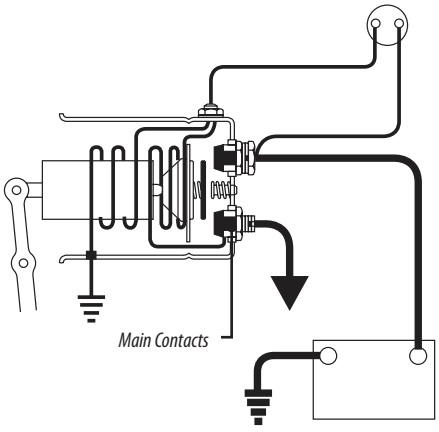


1. Connect the positive lead of the VOM to the starter motor terminal of the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, if there is no voltage displayed on the VOM, the main contacts are not functioning properly.

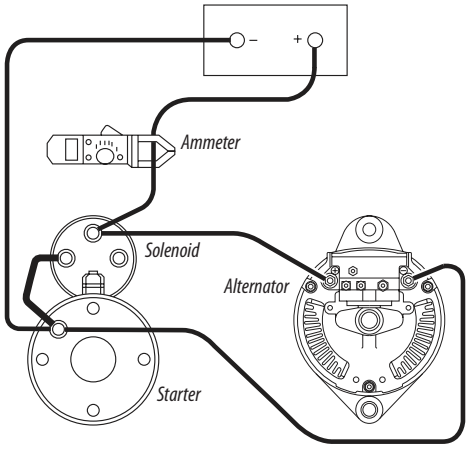
4. If there is voltage present at the solenoid terminal during Step 3, the problem is in the starter motor or its cabling.



5. If the first voltage check in Step 3 under Ignition/Run Test indicated normal voltage but slow or no cranking, the next step is to check the starter motor and its connections.

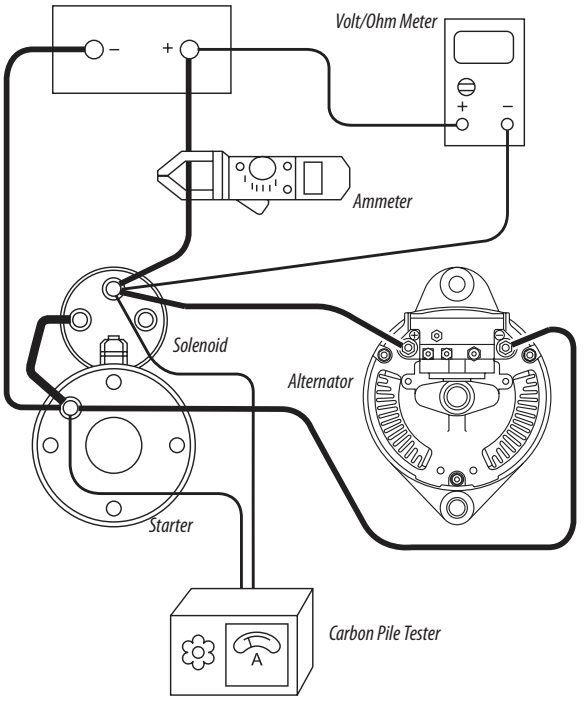
6. If the drive pinion jumps out of mesh with the flywheel ring gear, check for a broken or loose ground wire at the solenoid.

7. While attempting to crank the engine, place an ammeter on the positive battery cable. If the power drain is higher than the OEM specifications, the starter motor is defective. An exception would be if the engine was not properly tuned or is difficult to turn over; in which case, a new starter motor would be a temporary fix.



Slow Cranking

Sluggish cranking can be caused by a small amount of extra resistance in the cranking circuit. This extra resistance can come from loose or dirty (corroded) connections, or broken wires and/or cables. First check the positive cables and connections of the starter motor, then the negative circuit.



1. Connect the positive lead of a VOM to the positive battery terminal.
2. Position an ammeter between the solenoid and the positive terminal of the solenoid.
3. Connect the negative lead of the VOM to the positive terminal of the solenoid.
4. Connect the negative lead of the VOM to the negative battery post. This is the "unloaded" voltage. Record the reading; leave the VOM connected.
5. Connect one lead of a carbon pile tester to chassis ground.
6. Connect the other lead from the carbon pile tester to the positive terminal of the solenoid.
7. Adjust the carbon pile tester until the ammeter on the tester reads 500 amps.
8. Record the voltage display on the VOM; it should not be less than 0.4-volts less than the unloaded value.
9. Turn the carbon pile tester to the "OFF" position.
10. Connect the positive lead of the VOM to chassis ground.
11. Connect the negative lead of the VOM to the negative battery post. Record the reading; leave the VOM connected.
12. Position the ammeter in on the negative battery cable.
13. Turn on the carbon pile tester and adjust it to read 500 amps.
14. Record the voltage on the VOM; it should not drop more than 0.5-volts from the unloaded reading.
15. Turn the carbon pile tester to the OFF position.

16. If the voltage drop was more than 0.5-volts in step 8, the positive cabling is defective. Look for a broken cable or a loose or corroded connection.

17. If the voltage drop in step 14 is more than 0.4 volts, look for a problem in the negative cabling; look for broken or defective cables, and loose or corroded connections.

Final check at solenoid terminals.

1. Disconnect the carbon pile tester.

2. Disconnect the VOM.

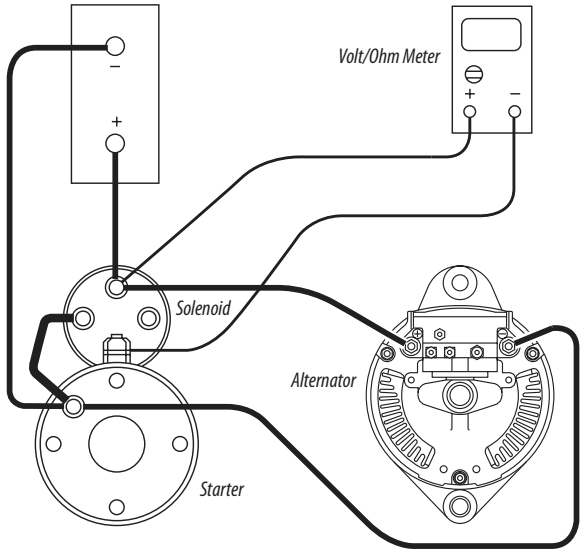
3. Remove the ammeter.

4. Connect the positive lead of the VOM to the positive (battery) terminal of the solenoid.

5. Set the VOM so that it can read the full battery volt-age; at least 14 volts.

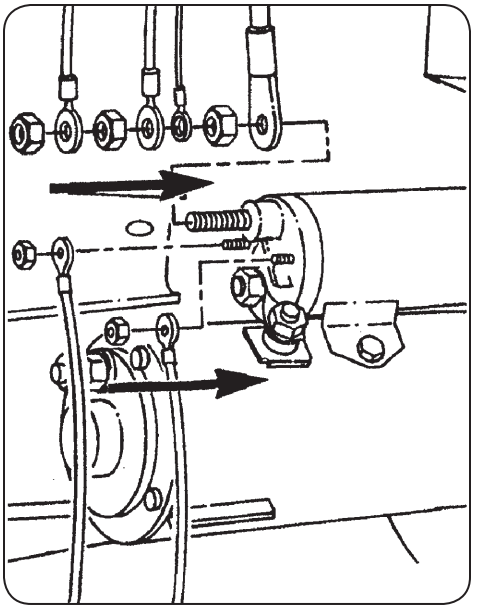
6. Connect the negative VOM lead to the starter motor terminal of the solenoid.

7. Crank the engine and record the voltage while cranking. There should be no more than 0.2 volts drop between the solenoid contacts while cranking.



8. The voltage reading in these last three tests (the positive cable check, the negative cable check and the solenoid test), should not total more than 1.0 volts. If the voltage drop is more than allowable, repeat the cable tests using a jumper cable. If the tests then indicate an acceptable drop, the cable(s) is (are) defective.

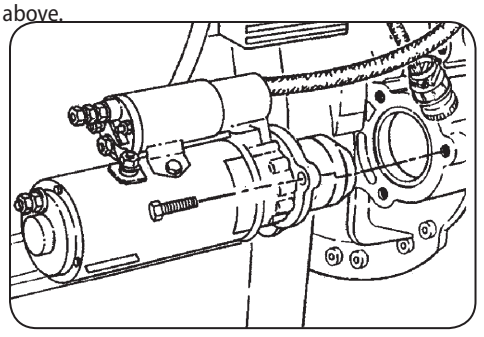
Starter Motor Removal



1. Disconnect the negative (ground) cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
2. Disconnect positive cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
3. Identify and tag each wire on the starter motor for reinstallation.
4. Remove all electrical connections from the starter motor. Be sure to identify and tag all electrical connection locations.
5. Remove 3 capscrews.
6. Remove starter motor from flywheel housing.

Starter Motor Installation

The starter motor is installed in the reverse order of the removal instructions above.



1. Carefully place the starter motor into position on the flywheel housing.
2. Install 3 capscrews (1). Torque to 32 ft lb (43 Nm). See Figure 8.
3. Being careful to observe the identification of the electrical wires, connect the wires to the appropriate terminal on the starter motor. See Figure 7.

WARNING ***Always remove the negative (-) cable from the battery terminal first. Always connect the negative (-) cable to the battery terminal last to avoid arcing that could ignite explosive battery gases.***

4. Install the positive cable on the battery post.
5. Install the negative cable on the battery post.

J-1939 Harness Diagnostics

1. Disconnect battery or J-1939 connector from the engine, ABS, transmission and instrument panel.

2. Measure resistance between pin A and pin B. Reading should be 60 ohms +/-1% (0.6 ohms).

3. Meassure continuity between shield (pin C) and ground. Reading should be minimal resistance.

4. Meassure resistance between pin A and ground. Reading should be infinity (maximum resistance).

5. Meassure resistance between pin B and ground. Reading should be infinity.

6. If all readings are correct, and problem appears to be intermittent:

   6.1 Inspect each connector for positive lock connection.

   6.2 Inspect for corrosion.

   6.3 Inspect for damage to connectors.

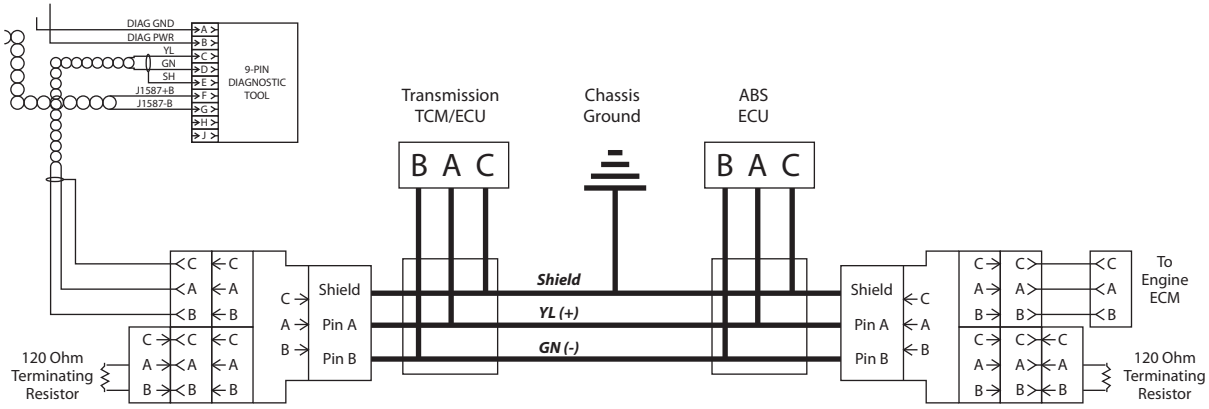
7. If resistance between pins A and B is 120 ohms, one of the terminating resistorsis missing or bad.

8. If reading between pins A and B is infinity:

   8.1 One of the connectors is unplugged.

   8.2 Both resistors are bad or missing.

   8.3 A connector is damaged



Chassis Wiring Schematics

The following pages contain the main wiring schematics applicable to most All American chassis. These are provided for your convenience when you are limited to use of the print manual. However, the Tech Reference DVD contains a duplicate set of these drawings which provides additional functionality to aid navigation while tracing circuits. When using the DVD, click the Electrical Schematics Chassis link in the Bookmarks pane. The first page of the Chassis Electrical Schematics group contains instructions on how to use the linking and navigation features.

The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged as occurs with bitmap formats. This also means that you may print the drawing to your own office or desktop printer while maintaining legibility even at significant reductions.

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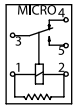
ABS, BENDIX EC-60 953
GEN 4, 3000 TRANSMISSION 955
GEN 4, 2000 TRANSMISSION 957

Wire Colors

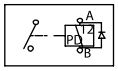
BL	BLUE
BK	BLACK
BN	BROWN
TN	TAN
WH	WHITE
YL	YELLOW
PK	PINK
OR	ORANGE
RD	RED
GN	GREEN
PU	PURPLE
GY	GRAY

Schematic Legend

PD	PDU PANEL
AC	AIR CLEANER BRACKET
IP	INSTRUMENT PANEL
FW	FIREWALL
SP	SHIFTER PANEL
DC	DCM



Micro Relay

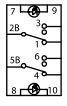


Heavy Duty Relay

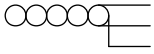
Fuse

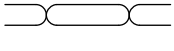
Voltage Stud

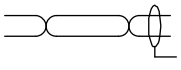
Shunt

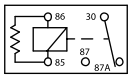


Switch Ngr Rocker (Non-typical)


3 Wire Twisting


2 Wire Twisting


2 Wire Twisting with Shield



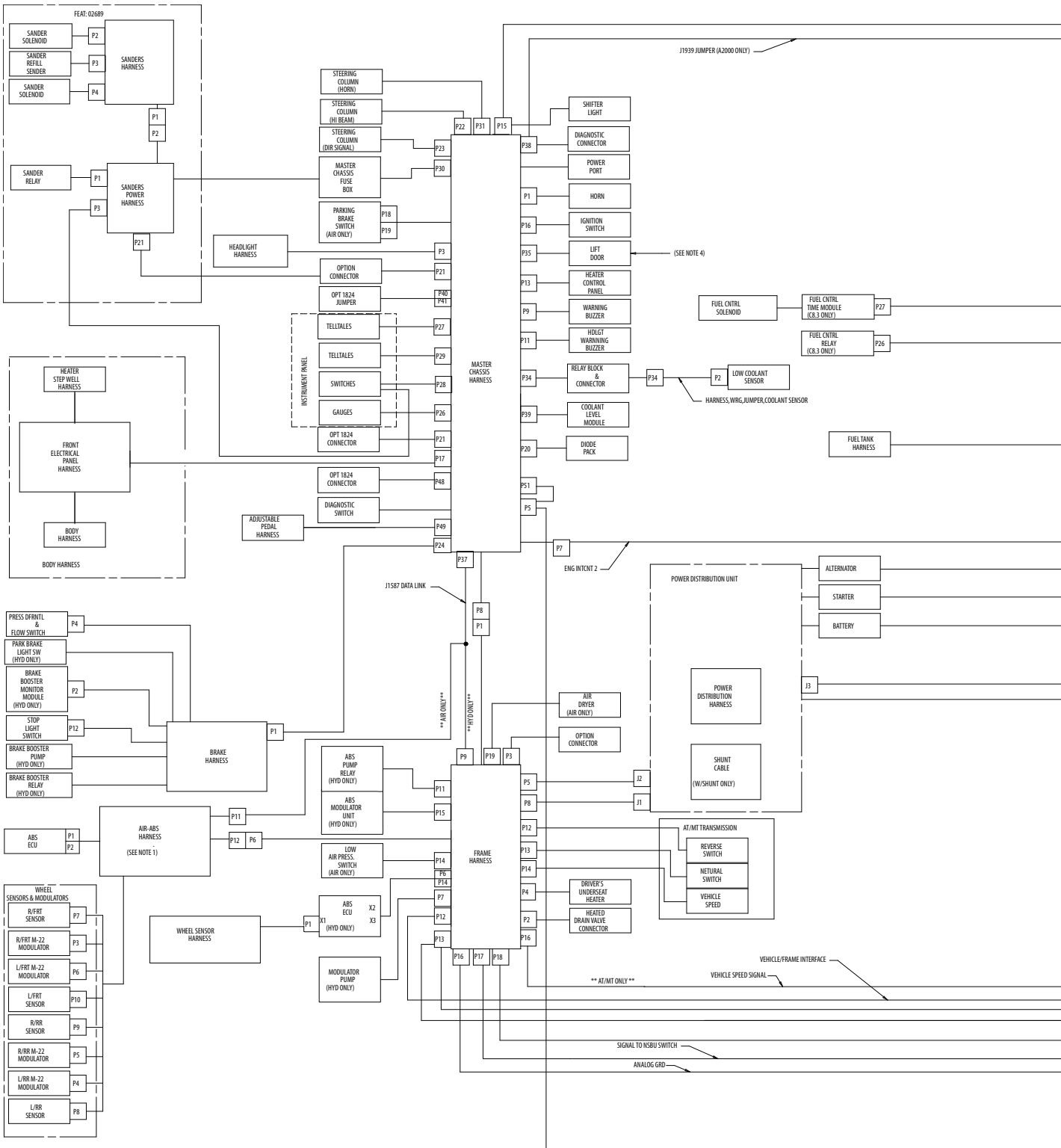
Mini Relay

Horn

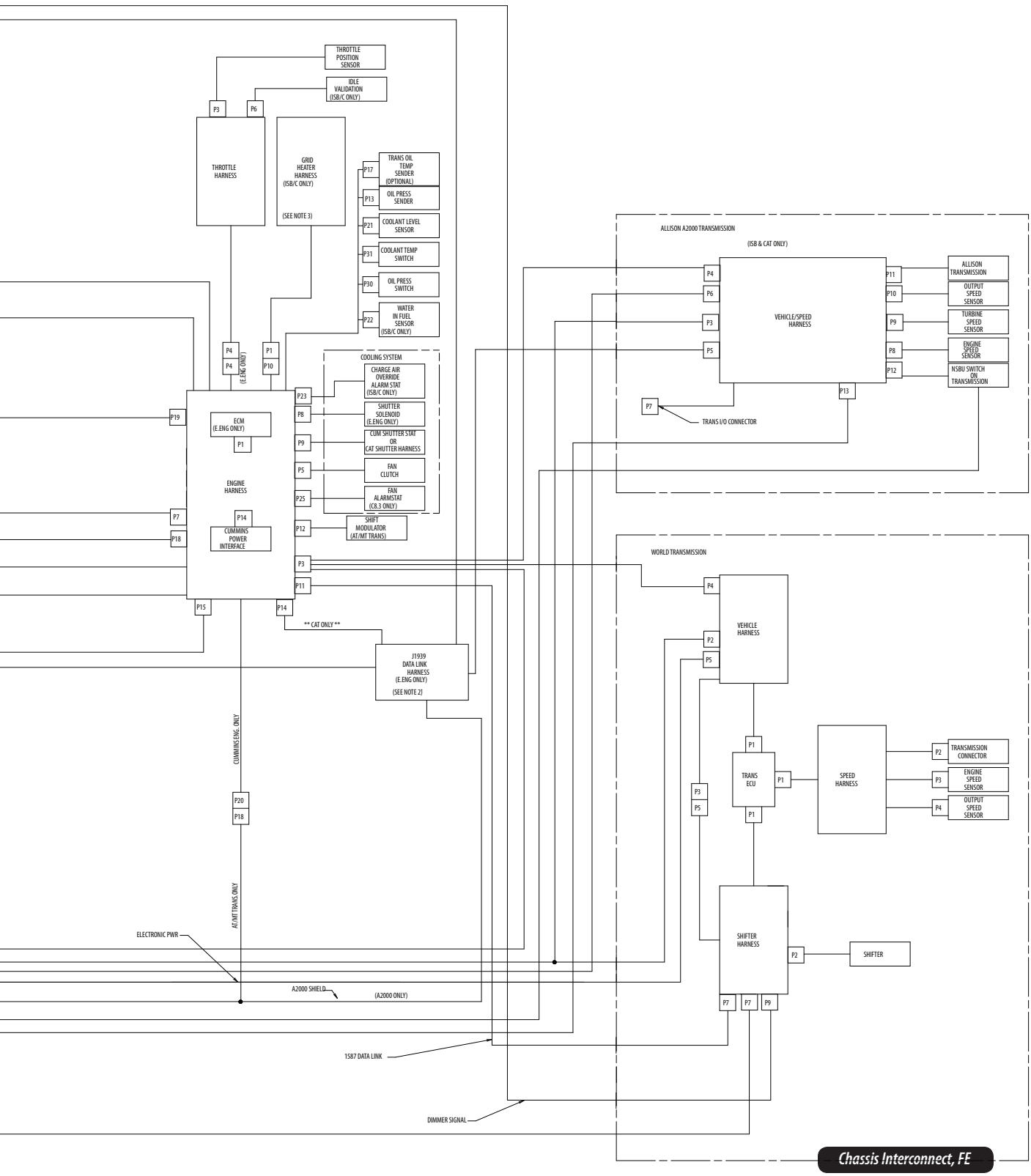
Speaker

Light

Circuit Breaker

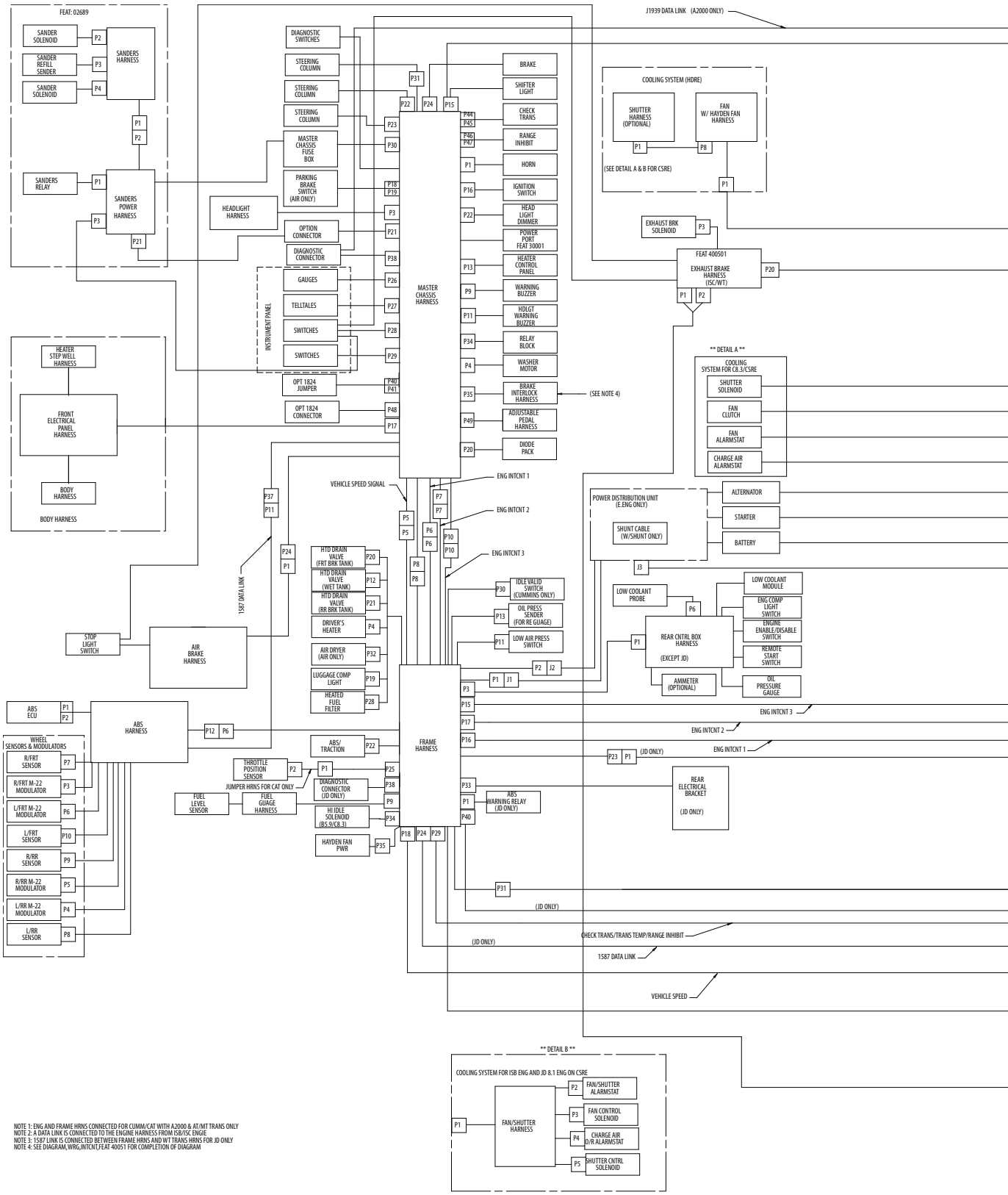


NOTE 1: ABS HARNESS IS INCORPORATED IN FRAME HARNESS FOR HYD-ABS
NOTE 2: FOR ISB/C, A J1939 LINK IS DIRECTLY CONNECTED TO ENGINE FROM LINK HRNS
NOTE 3: GRID HTR IS REPLACED BY INTAKE HTR FOR CAT ENGINE
NOTE 4: SEE DIAGRAM,WRG,INTCNT,FEAT 40051 FOR COMPLETION OF DIAGRAM

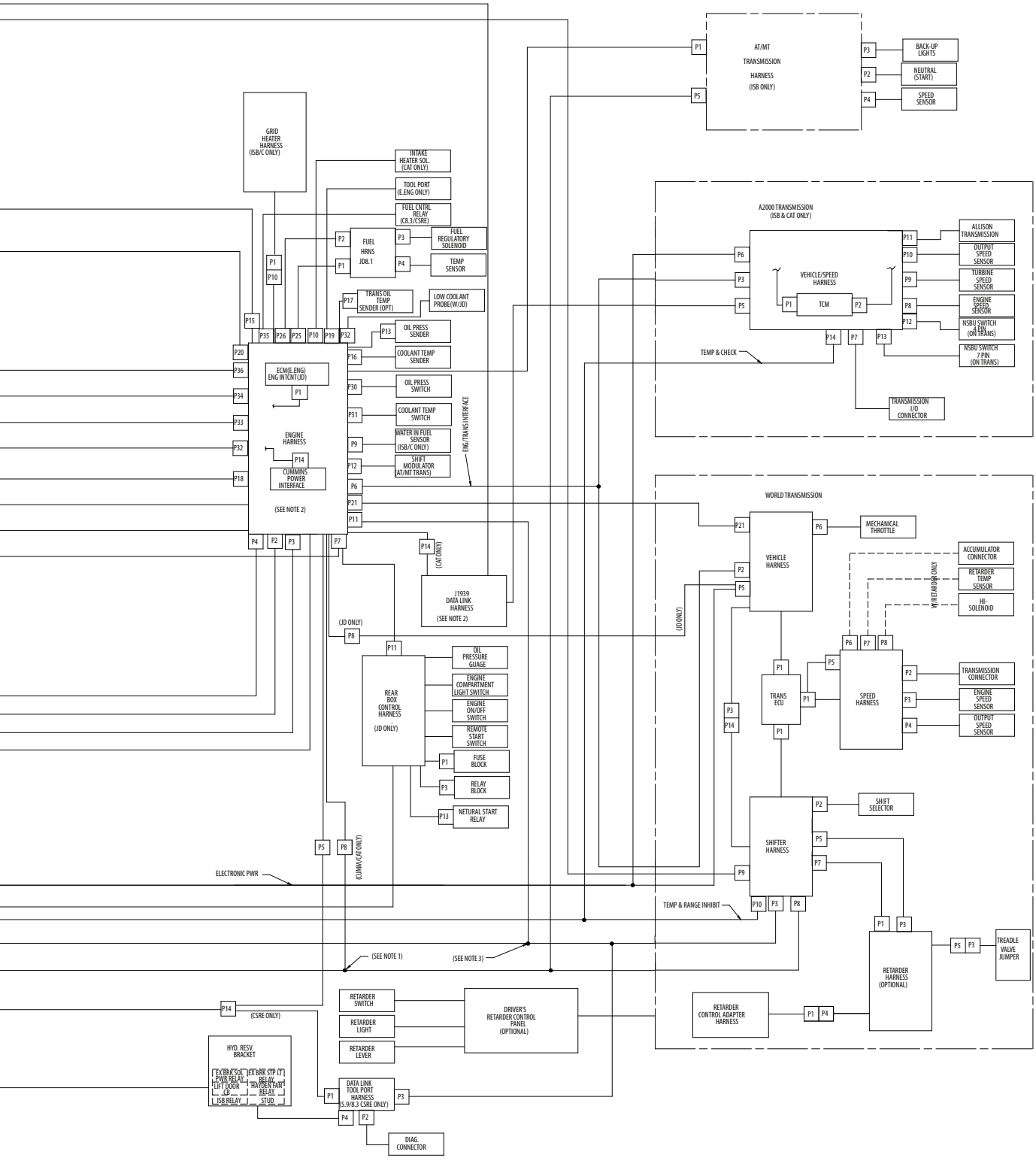


Chassis Interconnect, FE

0026443E



NOTE 1: ENG AND FRAME HRNS CONNECTED FOR CUMM/CAT WITH A2000 & AT/MT TRANS ONLY
NOTE 2: A DATA LINK IS CONNECTED TO THE ENGINE HARNESS FROM ISB/ISC ENGIE
NOTE 3: 1587 LINK IS CONNECTED BETWEEN FRAME HRNS AND WT TRANS HRNS FOR JD ONLY
NOTE 4: SEE DIAGRAM, WRG, INTCNT, FEAT 40051 FOR COMPLETION OF DIAGRAM



Chassis Interconnect, RE

0026444E

STEERING COLUMN
COLUMN GRD
HORN SIGNAL (GRD)
IGN
STEERING COLUMN HEADLGT HI BEAM
STEERING COLUMN
+12 BATT
LH DIR
RH DIR
IGNITION SWITCH
BAT
ST
IG 1
IG 2
ACC1
ACC2
HEADLIGHT HARNESS
HDLGT HI BEAM
HDLGT LO BEAM
PARK LGTS
WASHER MOTOR
GRD
ELECTRICAL PANEL CONNECTOR
IGN HOT
ACC HOT
HDLGT PWR
DRL
DRL PARK/TAIL PWR
TAIL LGTS
BACK-UP LGTS
CNTL HEADLIGHT
DOOR SW SIGNAL
ILLUMINATION
LIFT PWR RLY CNTL
STOP LIGHTS
VANDAL LOCK
REV MOTION SEN (OPT 222B)
CHASSIS GROUND
DORAN SCC WARN SIG
SPARE
PARK BRAKE
LIFT NOT STOWED SIG
REGENERATION SWITCH
SW RET GND (ENG)
ENG REGEN ON/OFF SW
1212AA WH 18 GA
2108 TN/WH 18 GA
1162D PK/BK 18 GA
1301C WH/OR 18 GA
1305 OR 18 GA
1120 BK 18 GA
1450A YL 18 GA
1451A DK GN 18 GA
1158 BK 14 GA
1008 PU 16 GA
1102B PK/BK 14 GA
1102A PK/BK 18 GA
1162A PK/BK 14 GA
1162B PK/BK 14 GA
1106A BK/YL 14 GA
1334 BK/WH 14 GA
1336 RD/BK 16 GA
1315B BN 16 GA
2102 BN 16 GA
1212B WH 14 GA
1168P PK/BK 14 GA
1106 BK/YL 14 GA
1301A WH/OR 14 GA
1337 RD/BK 16 GA
1335 RD/WH 14 GA
1336 RD/BK 16 GA
1315 BN 14 GA
1322 LT BL 16 GA
1323 DK GN 14 GA
1313 YL 14 GA
1317 GY 18 GA
1552B YL/BK 18 GA
1333C LT BL 18 GA
2501Z RD 16 GA
2102 BN 16 GA
1316B RD 16 GA.
2601 PK 16 GA
2432 GN 16 GA
1212CC WH 14 GA
2108B TN/WH 18 GA
1521H RD/BK 18 GA
LN5 SIG OR 18 GA
1206RR WH 18 GA
1444A TN/OR 18 GA
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1175 BK 14 GA
1338A BK 14 GA
1313 YL 14 GA
1450A YL 18 GA.
1313A YL 18 GA
1212H WH 14 GA
1212K WH 18 GA
1212J WH 18 GA
1212DD WH 18 GA
1168P PK/BK 14 GA
1168R PK/BK 16 GA
1171 BK 14 GA
1212N WH 18 GA.
1334B BK/WH 14 GA
1334A BK/WH 18 GA
1301B WH/OR 14 GA
1301A WH/OR 14 GA
1305 OR 18 GA
1212P WH 18 GA
1008 PU 16 GA
1168A PK/BK 18 GA
1168F PK/BK 14 GA
1008A PU 18 GA
1102E PK/BK 14 GA
2107A BN/WH 16 GA
1166C BK 14 GA
1166D BK 18 GA
2108B TN/WH 18 GA
1337B RD/BK 16 GA
1212P WH 18 GA
1521G RD/BK 18 GA
1175A BK 14 GA
2601 PK 16 GA
1009 YL 18 GA
1334B BK/WH 14 GA
1008C PU 18 GA
1008A PU 18 GA.
1008B PU 18 GA.
2107 BN/WH 16 GA
1166A BK 18 GA
1198 PU 18 GA
1166B BK 14 GA
1460 YL 18 GA
2108 TN/WH 18 GA
1212E WH 18 GA
1212L WH 18 GA
1521J RD/BK 18 GA
1521F RD/BK 18 GA
1316E RD 16 GA
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
1212VV WH 16 GA
1212A WH 12 GA
GROUND STUD
2107 BN/WH 16 GA
1212WW WH 16 GA
1102J PK/BK 18 GA
1521 RD/BK 18 GA
VEH SPEED, 3 MPH
IGN
DOOR SW SIGNAL
THROT INTLCK SW/ELEC GRD
LIFT AUTH INTLK
STOP SIGNAL
LIFT PWR RLY CNTL
INTERLOCK POWER
WARNING SIGNAL
12V FOR CHASSIS GND
PARK BRKE (+) SIGNAL
STOP LIGHT POWER
1168R PK/BK 14 GA
1168F PK/BK 14 GA
1212Y WH 14 GA
1521A RD/BK 18 GA
1316A RD 16 GA
1159C BK 14 GA
2401 TN/OR 18 GA
1162A PK/BK 14GA
2501Y RD 16 GA
1316C RD 16 GA
2501Z RD 16GA
2501AA RD 16 GA
1106 OR BK /OR 18 GA
1338 LT BL 18GA
1107 DK BL 18GA
1212L WH 18 GA
1316J RD 16GA
1159B BK 16 GA
2305 OR/BN 14 GA
2309 BN 14 GA.
1168W PK/BK 18GA
WIF SENSOR
DRV HTR LOW
DRV HTR HI
HAMMETER/ALT
2305 OR/BN 14 GA
2309 BN 14 GA
1460A BK 16 GA
1179E BK 16 GA
1216S WH 12 GA
1162H PK/BK 18 GA
1008C PU 18 GA
1316E RD 18GA
1221B BL 16GA
2432 GN 16 GA
1510Y OR BL 18 GA
1206P WH 14GA
1115G BK 18 GA
1212Z WH 18 GA
1338 LT BL 18GA
1212WW WH 18 GA
1331J LT BL 18 GA
1108G PK/BK 16GA
1168H PK/BK 16 GA
1212PP WH 18 GA
1168J PK/BK 16 GA
P1 HORN
P18
PARKING BRAKE SWITCH (AIR)
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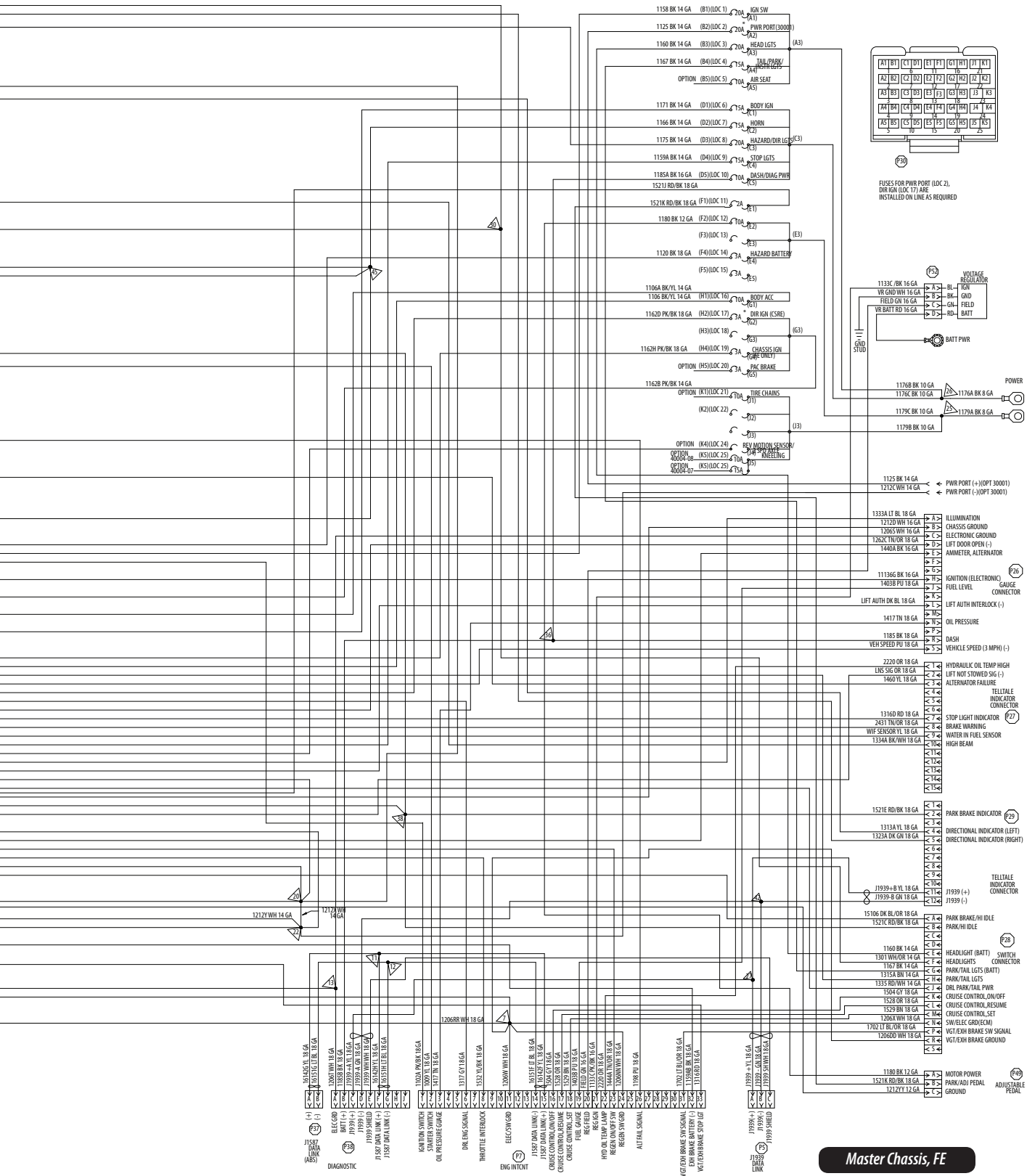
P35 LIFT DOOR
P29 BRAKE
P10 SHIFTER
P13 HEATER CONTROL PANEL
P8 FRAME COMPONENTS
P21 OPTION CONNECTOR
HORN PWR
GROUND
VEHICLE SPEED, 3 MPH
IGN
DOOR SW SIGNAL
THROT INTLCK SW/ELEC GRD
LIFT AUTH INTLK
STOP SIGNAL
LIFT PWR RLY CNTL
INTERLOCK POWER
WARNING SIGNAL
12V FOR CHASSIS GND
PARK BRKE (+) SIGNAL
STOP LIGHT POWER
WORLD TRANS (OPTIONAL)
IGN DROPOUT
WIF SENSOR
DRV HTR LOW
DRV HTR HI
HAMMETER/ALT
REV MOTION SEN (OPT)
CHASSIS GND
IGN
REMOTE START
BRAKE SIGNAL(+)
BACKUP LGTS
REV MOT SEN (OPT)
MULTIPLEX/PWR/VH BUSE 5AC
ELECTRONIC GRD
IGN ELECTRONIC POWER
AIR SUSP GRD
ILLUMINATION GRD
ILLUMINATION
AIR SUSP IGN
GROUND
IGNITION DROPOUT


1158 BK 14 GA (B1)(LOC 1) 20A IGN SW (A1)
1125 BK 14 GA (B2)(LOC 2) 20A PWR PORT(30001) (A2)
1160 BK 14 GA (B3)(LOC 3) 20A HEAD LGTS (A3)
1167 BK 14 GA (B4)(LOC 4) 15A TAIL/PARK/ MARK LGTS (A4)
OPTION (B5)(LOC 5) 10A AIR SEAT (A5)
1171 BK 14 GA (D1)(LOC 6) 15A BODY IGN (C1)
1166 BK 14 GA (D2)(LOC 7) 15A HORN (C2)
1175 BK 14 GA (D3)(LOC 8) 20A HAZARD/DIR LGTS (C3)
1159A BK 14 GA (D4)(LOC 9) 15A STOP LGTS (C4)
1185A BK 16 GA (D5)(LOC 10) 10A DASH/DIAG PWR (C5)
1521J RD/BK 18 GA
1521K RD/BK 18 GA (F1)(LOC 11) 2A (E1)
1180 BK 12 GA (F2)(LOC 12) 10A (E2)
(F3)(LOC 13) (E3)
1120 BK 18 GA (F4)(LOC 14) 3A HAZARD BATTERY (E4)
(F5)(LOC 15) 3A (E5)
1106A BK/YL 14 GA
1106 BK/YL 14 GA (H1)(LOC 16) 10A BODY ACC (G1)
1162D PK/BK 18 GA (H2)(LOC 17) 3A * DIR IGN (CSRE) (G2)
(H3)(LOC 18) (G3)
1162H PK/BK 18 GA (H4)(LOC 19) 3A CHASSIS IGN (RE ONLY)
OPTION (H5)(LOC 20) 3A PAC BRAKE (G5)
1162B PK/BK 14 GA
OPTION (K1)(LOC 21) 10A TIRE CHAINS (J1)
(K2)(LOC 22) (J2)
(J3)
OPTION (K4)(LOC 24) REV MOTION SENSOR/ 3A ALARM
OPTION 40004-08 (K5)(LOC 25) 10A KNEELING
OPTION 40004-07 (K5)(LOC 25) 15A
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VR GND WH 16 GA BK- GND
FIELD GN 16 GA GN- FIELD
VR BATT RD 16 GA RD- BATT
GND STUD
BATT PWR
POWER
1176B BK 10 GA
1176C BK 10 GA
J26 1176A BK 8 GA
1179C BK 10 GA
J25 1179A BK 8 GA
1179B BK 10 GA
1125 BK 14 GA PWR PORT (+)(OPT 30001)
1212CWH 14 GA PWR PORT (-)(OPT 30001)
1333A LT BL 18 GA ILLUMINATION
1212D WH 16 GA CHASSIS GROUND
1206S WH 16 GA ELECTRONIC GROUND
1262C TN/OR 18 GA LIFT DOOR OPEN (-)
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11136G BK 16 GA IGNITION (ELECTRONIC)
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GAUGE CONNECTOR
LIFT AUTH DK BL 18 GA LIFT AUTH INTERLOCK (-)
1417 TN 18 GA OIL PRESSURE
1185 BK 18 GA DASH
VEH SPEED PU 18 GA VEHICLE SPEED (3 MPH) (-)
2220 OR 18 GA HYDRAULIC OIL TEMP HIGH
LNS SIG OR 18 GA LIFT NOT STOWED SIG (-)
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2431 TN/OR 18 GA BRAKE WARNING
WIF SENSOR YL 18 GA WATER IN FUEL SENSOR
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1521E RD/BK 18 GA PARK BRAKE INDICATOR
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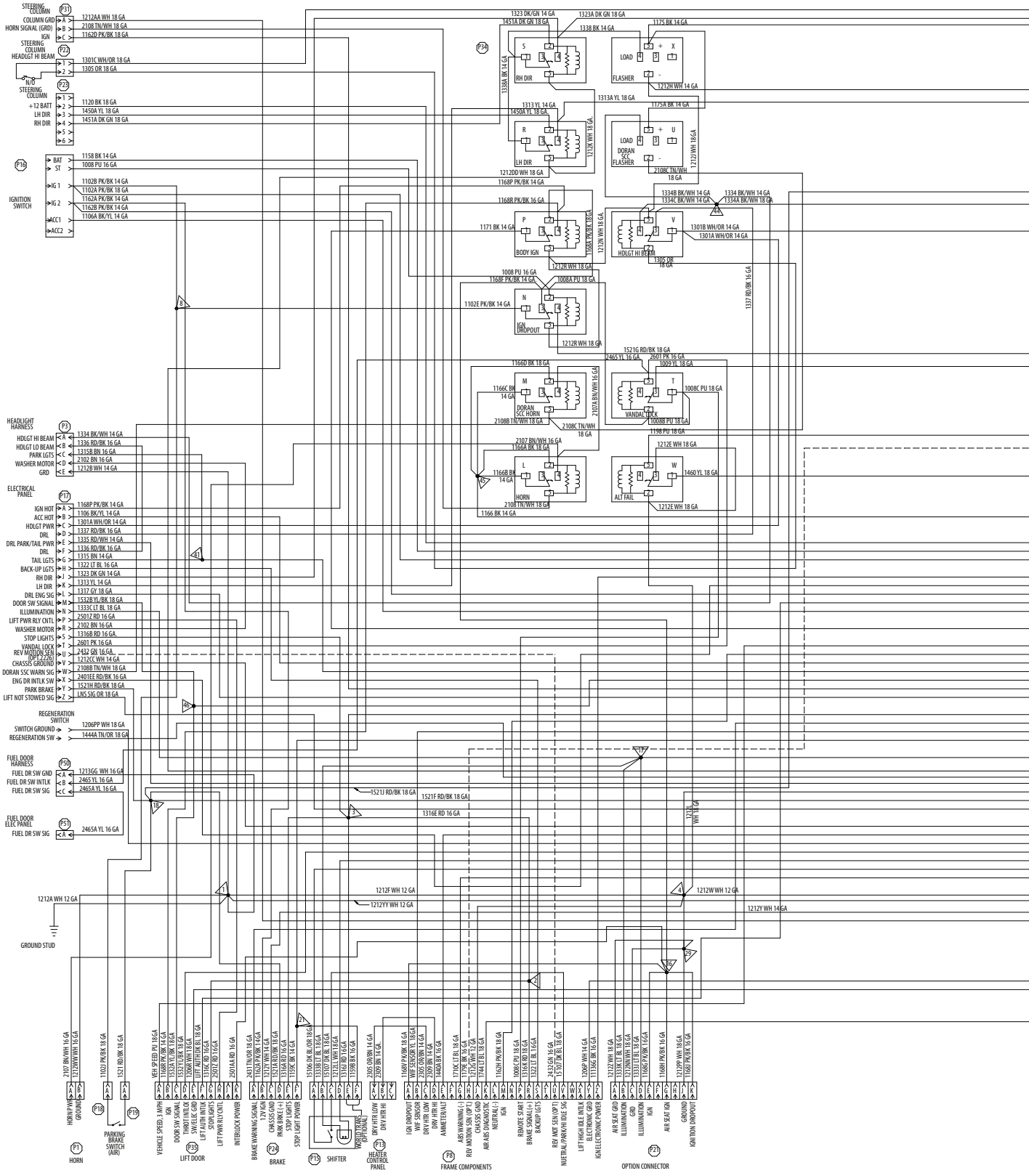
1323A DK GN 18 GA DIRECTIONAL INDICATOR (RIGHT)
TELLTALE INDICATOR CONNECTOR
J1939+8 YL 18 GA J1939 (+)
J1939-8 GN 18 GA J1939 (-)
15106 DK BL/OR 18 GA PARK BRAKE/HI IDLE
1521C RD/BK 18 GA PARK/HI IDLE
P28
1160 BK 14 GA HEADLIGHT (BATT)
1301 WH/OR 14 GA HEADLIGHTS
SWITCH CONNECTOR
1167 BK 14 GA PARK/TAIL LGTS (BATT)
1315A BN 14 GA PARK/TAIL LGTS
1335 RD/WH 14 GA DRL PARK/TAIL PWR
1504 GY 18 GA CRUISE CONTROL ON/OFF
1528 OR 18 GA CRUISE CONTROL RESUME
1529 BN 18 GA CRUISE CONTROL SET
1206X WH 18 GA SW/ELEC GRD(ECM)
1702 LT BL/OR 18 GA VGT/EXH BRAKE SW SIGNAL
1206DD WH 18 GA VGT/EXH BRAKE GROUND
P49
1180 BK 12 GA MOTOR POWER
1521K RD/BK 18 GA PARK/ADJ PEDAL GROUND
1212Y YL 12 GA
ADJUSTABLE PEDAL
1212Y WH 14 GA
1212Z WH 14 GA
1206RR WH 18 GA
J1587 DATA LINK (ABS)
P37
DIAGNOSTIC
P38
ENG INTCNT
P7
J1939 DATA LINK
P5
IGNITION SWITCH
STARTER SWITCH
OIL PRESSURE GUAGE
DRL ENG SIGNAL
THROTTLE INTERLOCK
ELEC GRD
J1587 DATA LINK(+)
J1587 DATA LINK(-)
CRUISE CONTROL ON/OFF
CRUISE CONTROL RESUME
CRUISE CONTROL SET
ENG BRAKE
REG FEED
REG IGN
HYD OIL TEMP LAMP
REGEN ON/OFF SW
REGEN SW GRD
ALT FAIL SIGNAL
VGT/EXH BRAKE SW SIGNAL
CAN BRAKE BATTERY (-)
VGT/EXHBRAKE STOP LGT
J1939(+)
J1939(-)
J1939 SHIELD
Master Chassis, FE
0122822C


STEERING COLUMN P31
COLUMN GRD A
HORN SIGNAL (GRD) B
IGN C
1212AA WH 18 GA
2108 TN/WH 18 GA
1162D PK/BK 18 GA
STEERING COLUMN HEADLGT HI BEAM P22
1301C WH/OR 18 GA
1305 OR 18 GA
N/O
STEERING COLUMN P23
+12 BATT
LH DIR
RH DIR
1120 BK 18 GA
1450A YL 18 GA
1451A DK GN 18 GA
P16
BAT
ST
IG 1
IG 2
ACC1
ACC2
IGNITION SWITCH
1158 BK 14 GA
1008 PU 16 GA
1102B PK/BK 14 GA
1102A PK/BK 18 GA
1162A PK/BK 14 GA
1162B PK/BK 14 GA
1106A BK/YL 14 GA
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HDLGT LO BEAM B
PARK LGTS C
WASHER MOTOR D
GRD E
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1336 RD/BK 16 GA
1315B BN 16 GA
2102 BN 16 GA
1212B WH 14 GA
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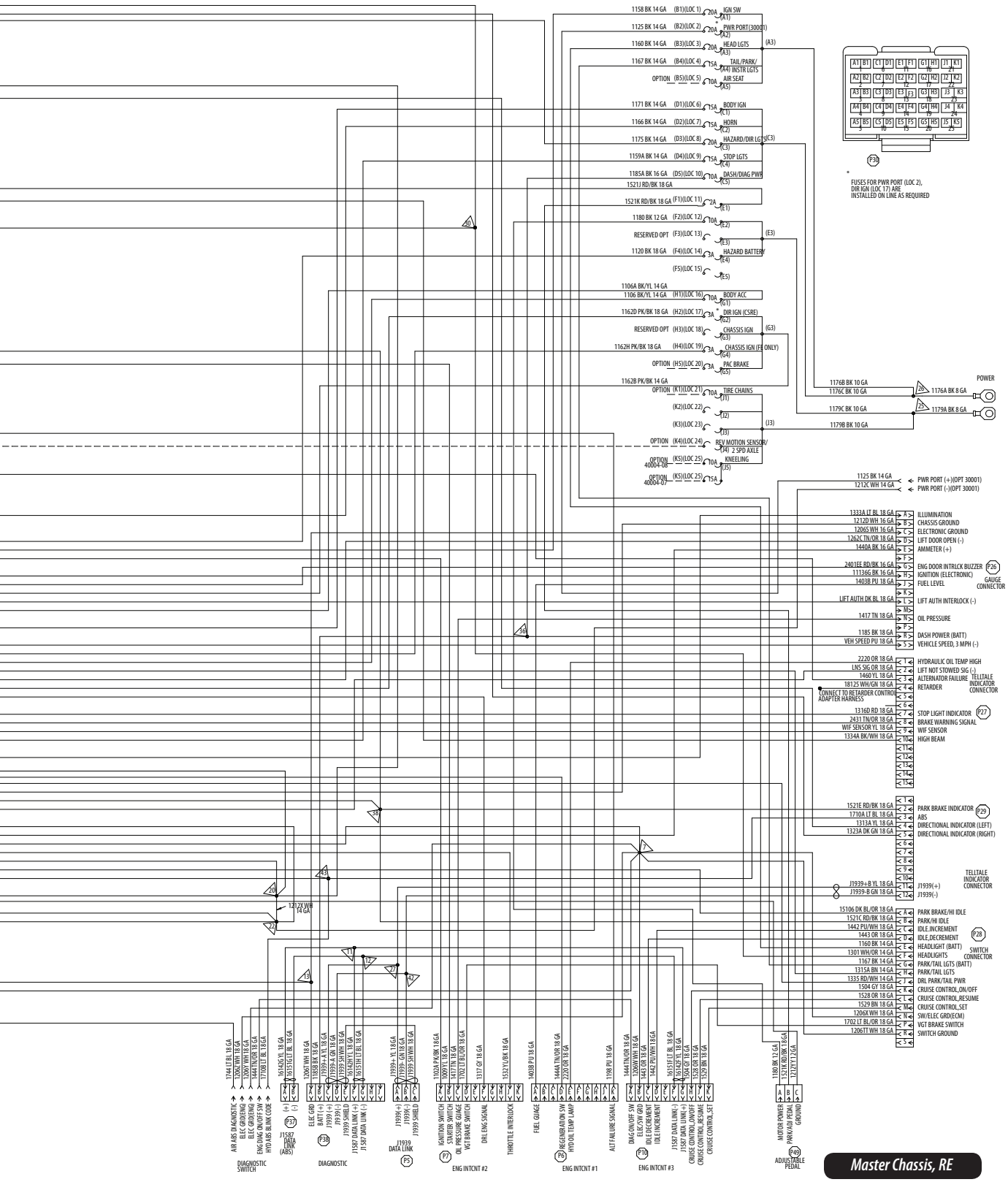
ACC HOT B
HDLGT PWR C
DRL D
DRL PARK/TAIL PWR E
DRL F
TAIL LGTS G
BACK-UP LGTS H
RH DIR J
LH DIR K
DRL ENG SIG L
DOOR SW SIGNAL M
ILLUMINATION N
LIFT PWR RLY CNTL P
WASHER MOTOR R
STOP LIGHTS S
VANDAL LOCK REV MOTOR SER (OPT 2220) T
CHASSIS GROUND U
DORAN SSC WARN SIG V
ENG DR INTLK SW W
PARK BRAKE X
LIFT NOT STOWED SIG Y
1168P PK/BK 14 GA
1106 BK/YL 14 GA
1301A WH/OR 14 GA
1337 RD/BK 16 GA
1335 RD/WH 14 GA
1336 RD/BK 16 GA
1315 BN 16 GA
1322 LT BL 16 GA
1322 DK GN 14 GA
1313 YL 14 GA
1317 GY 18 GA
1532B YL/BK 18 GA
1333C LT BL 18 GA
2501Z RD 16 GA
2102 BN 16 GA
1316B RD 16 GA
2601 PK 16 GA
2432 GN 16 GA
1212CC WH 14 GA
2108B TN/WH 18 GA
2401EE RD/BK 16 GA
1521H RD/BK 18 GA
LNS SIG OR 18 GA
REGENERATION SWITCH
SWITCH GROUND
REGENERATION SW
1206PP WH 18 GA
1444A TN/OR 18 GA
FUEL DOOR HARNESS P50
FUEL DR SW GND A
FUEL DR SW INTLK B
FUEL DR SW SIG C
1213GG WH 16 GA
2465 YL 16 GA
2465A YL 16 GA
FUEL DOOR ELEC PANEL P51
FUEL DR SW SIG A
2465A YL 16 GA
1212A WH 12 GA
GROUND STUD
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1125S BK 14 GA
P34
S
RH DIR
LOAD
FLASHER
+ X -
1212H WH 14 GA
1313A YL 18 GA
1313 YL 14 GA
1450A YL 18 GA
1175A BK 14 GA
R
LH DIR
LOAD
DORAN SCC FLASHER
+ U -
1212X WH 18 GA
1212W WH 18 GA
2108C TN/WH 18 GA
1212DD WH 18 GA
1168P PK/BK 14 GA
1168R PK/BK 16 GA
1334B BK/WH 14 GA
1334C BK/WH 14 GA
1334 BK/WH 14 GA
1334A BK/WH 18 GA
4A
1171 BK 14 GA
P
BODY IGN
1168A PK/OR 18 GA
1212N WH 18 GA
V
HDLGT HI BEAM
1301B WH/OR 14 GA
1301A WH/OR 14 GA
1305 OR 18 GA
1212R WH 18 GA
1008 PU 16 GA
1168F PK/BK 14 GA
1008A PU 18 GA
1102E PK/BK 14 GA
N
IGN DROPOUT
1212R WH 18 GA
1337 RD/BK 16 GA
1521G RD/BK 18 GA
2465 YL 16 GA
2601 PK 16 GA
1009 YL 18 GA
1166D BK 18 GA
1166C BK 14 GA
M
DORAN SCC HORN
2108B TN/WH 18 GA
2107A BK/WH 16 GA
2108C TN/WH 18 GA
T
VANDAL LOCK
1008BC PU 18 GA
1008B PU 18 GA
2107 BN/WH 16 GA
1166A BK 18 GA
1166B BK 14 GA
L
HORN
2108 TN/WH 18 GA
1166 BK 14 GA
1212E WH 18 GA
W
ALT FAIL
1460 YL 18 GA
1212E WH 18 GA
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
1212Y WH 14 GA
1521J RD/BK 18 GA
1521F RD/BK 18 GA
1316E RD 16 GA
1212L WH 14 GA
2107 BK/WH 16 GA
1212H WH 16 GA
1102J PK/BK 18 GA
1521 RD/BK 18 GA
HORN/PWM GROUND
P1 HORN
P18
P19
PARKING BRAKE SWITCH (AIR)
VEH SPEED, PU 18 GA
1168B PK/BK 14 GA
1532A YL/BK 18 GA
1532Y DK BL 18 GA
1206B WH 18 GA
LIFT AUTH INTLK
SW ELEC GRD
LIFT PWR RLY CNTL
2501Z RD 16 GA
2901A RD 16 GA
INTERLOCK POWER
P35 LIFT DOOR
2451TN/OR 18 GA
1532A YL/BK 18 GA
1212A WH 14 GA
1521A RD/BK 18 GA
1316A RD 16 GA
1159K BK 14 GA
BRAKE WARNING SIGNAL
12V IGN
CHASSIS GND
PARK BRAKE (+)
STOP LIGHTS
STOP LIGHT POWER
P24 BRAKE
15106 DK BL 18 GA
1212C WH 18 GA
1507J DK BL 18 GA
1212L WH 18 GA
1316J RD 16 GA
1159B BK 16 GA
P15 SHIFTER
2305 OR/BK 14 GA
2309 BK 14 GA
WASHER PUMP (OPTIONAL)
P13 HEATER CONTROL PANEL
DRV HTR LOW
DRV HTR HI
1168Y PK/OR 18 GA
WIF SENSOR
2305 OR/BK 14 GA
2309 BK 14 GA
IGN DROPOUT
DRV HTR LOW
DRV HTR HI
AAMETER/AUX
1440A BK 16 GA
P8 FRAME COMPONENTS
170C LT BL 18 GA
179E BK 16 GA
172G WH 12 GA
1744 LT BL 18 GA
ABS WARNING (-)
REV ANTIDIN SEN (OPT)
CHASSIS GND
AIR ABS DIAGNOSTIC
NEUTRAL (-)
IGN
1162H PK/BK 18 GA
1008C PU 18 GA
1316A RD 18 GA
1322 LT BL 16 GA
REMOTE START
BRAKE SIGNAL (+)
BACKUP LGTS
2432 GN 16 GA
1510Y DK BL 18 GA
REV ANT SEN (OPT)
NEUTRAL/PARK/PH IDLE SIG
1206P WH 14 GA
1159A BK 16 GA
LIFT HIGH IDLE INTLK
ELECTRONIC GRD
IGN ELECTRONIC POWER
1212Z WH 18 GA
1333K LT BL 18 GA
1212WW WH 18 GA
1333J LT BL 18 GA
1106BE PK/BK 16 GA
1169H PK/BK 16 GA
1212PP WH 18 GA
1168J PK/BK 16 GA
AIR SEAT GRD
ILLUMINATION GRD
ILLUMINATION
IGN
AIR SEAT IGN
GROUND
IGNITION DROPOUT
P21 OPTION CONNECTOR



Master Chassis, RE

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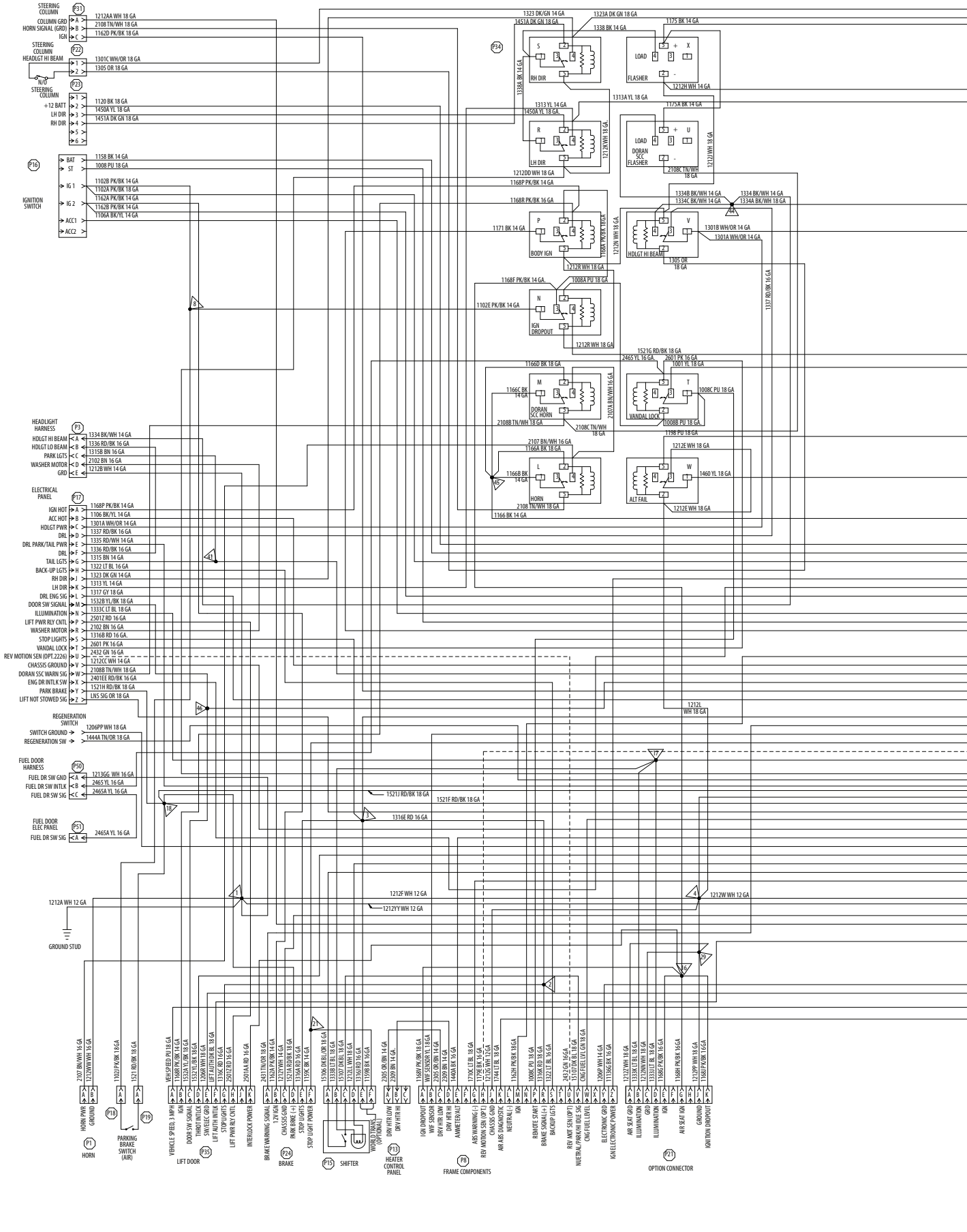
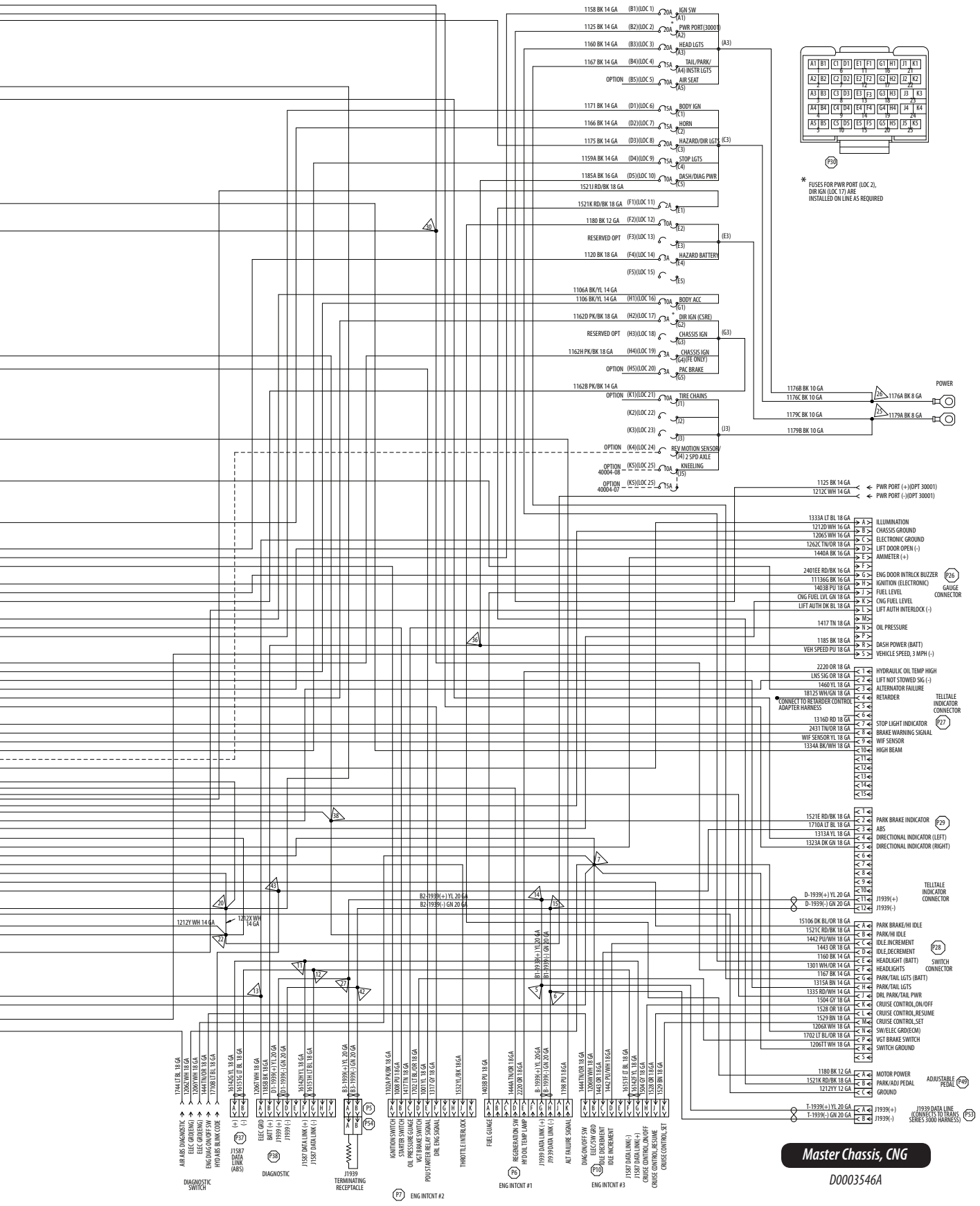

STEERING COLUMN
P31
COLUMN GRD
HORN SIGNAL (GRD)
IGN
1212AA WH 18 GA
2108 TN/WH 18 GA
1162D PK/BK 18 GA
STEERING COLUMN
HEADLGT HI BEAM
P22
1301C WH/OR 18 GA
1305 OR 18 GA
N/O
STEERING COLUMN
P23
+12 BATT
LH DIR
RH DIR
1120 BK 18 GA
1450A YL 18 GA
1451A DK GN 18 GA
P16
IGNITION SWITCH
BAT
ST
IG 1
IG 2
ACC1
ACC2
1158 BK 14 GA
1008 PU 18 GA
1102B PK/BK 14 GA
1102A PK/BK 18 GA
1162A PK/BK 14 GA
1162B PK/BK 14 GA
1106A BK/YL 14 GA
HEADLIGHT HARNESS
P3
HDLGT HI BEAM
HDLGT LO BEAM
PARK LGTS
WASHER MOTOR
GRD
1334 BK/WH 14 GA
1336 RD/BK 16 GA
1315B BN 16 GA
2102 BN 16 GA
1212B WH 14 GA
ELECTRICAL PANEL
P17
IGN HOT
ACC HOT
HDLGT PWR
DRL
DRL PARK/TAIL PWR
DRL
TAIL LGTS
BACK-UP LGTS
RH DIR
LH DIR
DRL ENG SIG
DOOR SW SIGNAL
ILLUMINATION
LIFT PWR RLY CNTL
WASHER MOTOR
STOP LIGHTS
VANDAL LOCK
REV MOTION SEN (OPT.2226)
CHASSIS GROUND
DORAN SSC WARN SIG
ENG DR INTLK SW
PARK BRAKE
LIFT NOT STOWED SIG
1168P PK/BK 14 GA
1106 BK/YL 14 GA
1301A WH/OR 14 GA
1337 RD/BK 16 GA
1335 RD/WH 14 GA
1336 RD/BK 16 GA
1315 BN 14 GA
1322 LT BL 16 GA
1323 DK GN 14 GA
1313 YL 14 GA
1317 GY 18 GA
1532B YL/BK 18 GA
1333C LT BL 18 GA
2501Z RD 16 GA
2102 BN 16 GA
1316B RD 16 GA.
2601 PK 16 GA
2432 GN 16 GA
1212CC WH 14 GA
2108B TN/WH 18 GA
2401EE RD/BK 16 GA
1521H RD/BK 18 GA
LNS SIG OR 18 GA
REGENERATION SWITCH
SWITCH GROUND
REGENERATION SW
1206PP WH 18 GA
1444A TN/OR 18 GA
FUEL DOOR HARNESS
P50
FUEL DR SW GND
FUEL DR SW INTLK
FUEL DR SW SIG
1213GG WH 16 GA
2465 YL 16 GA
2465A YL 16 GA
FUEL DOOR ELEC PANEL
P51
FUEL DR SW SIG
2465A YL 16 GA
1212A WH 12 GA
GROUND STUD
P34
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1175 BK 14 GA
1338A BK 14 GA
RH DIR
FLASHER
1212H WH 14 GA
1313A YL 18 GA
1313 YL 14 GA
1450A YL 18 GA
1175A BK 14 GA
1212K WH 18 GA
LH DIR
DORAN SCC FLASHER
1212J WH 18 GA
1212DD WH 18 GA
2108C TN/WH 18 GA
1168P PK/BK 14 GA
1168R PK/BK 16 GA
1171 BK 14 GA
BODY IGN
1168A PK/BK 18 GA
1212R WH 18 GA
1334B BK/WH 14 GA
1334C BK/WH 14 GA
1334A BK/WH 18 GA
HDLGT HI BEAM
1301B WH/OR 14 GA
1301A WH/OR 14 GA
1305 OR 18 GA
1168F PK/BK 14 GA
1008A PU 18 GA
1102E PK/BK 14 GA
IGN DROPOUT
1212R WH 18 GA
1337 RD/BK 16 GA
1166D BK 18 GA
1166C BK 14 GA
DORAN SCC HORN
2107A BN/WH 16 GA
2108B TN/WH 18 GA
2108C TN/WH 18 GA
1521G RD/BK 18 GA
2465 YL 16 GA
2601 PK 16 GA
1001 YL 18 GA
1008C PU 18 GA
VANDAL LOCK
1008B PU 18 GA
1198 PU 18 GA
2107 BN/WH 16 GA
1166A BK 18 GA
1166B BK 14 GA
HORN
2108 TN/WH 18 GA
1166 BK 14 GA
1212E WH 18 GA
1460 YL 18 GA
ALT FAIL
1212E WH 18 GA
1212L WH 18 GA
1521J RD/BK 18 GA
1521F RD/BK 18 GA
1316E RD 16 GA
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
2107 BK/WH 16 GA
1212WW WH 16 GA
1102J PK/BK 18 GA
1521D RD/BK 18 GA
HORN PWR
GROUND
P1
HORN
P18
PARKING BRAKE SWITCH (AIR)
P19
VEH SPEED 3 MPH
1168R PK/BK 14 GA
1168F PK/BK 14 GA
1532A YL/BK 18 GA
1532YL OR 18 GA
1206R WH 18 GA
1316C RD 16GA
2501Z RD 16 GA
2501AA RD 16 GA
VEHICLE SPEED
IGN
DOOR SW SIGNAL
THROT INTLCK
SW/ELEC GRD
LIFT FAUTH INTLK
LIFT FAUTH DK. 18 GA
LIFT PWR RLY CNTL
INTERLOCK POWER
P35
LIFT DOOR
2431 TN/OR 18 GA
1212W WH 18 GA
1212V WH 18 GA
1521A RD/BK 18 GA
1316A RD 16 GA
1159C BK 14 GA
BRAKE WARNING SIGNAL
12V IGN
CHASSIS GND
PARK BRKE (+)
STOP LIGHTS
STOP LIGHT POWER
P24
BRAKE
15106 DK/BL/OR 18 GA
1333B LT BL 18 GA
15107 DK/BL 18 GA
1212L WH 18 GA
1159B BK 16GA
P15
SHIFTER
2305 DK/BN 14 GA
2309 BK 14 GA
WORLD TRANS (OPTIONAL)
DRV HTR LOW
DRV HTR HI
P13
HEATER CONTROL PANEL
1168W PK/BK 18 GA
WIF SENSOR YEL 18GA
2305 DK/BN 14 GA
2309 BK 14 GA
14406A DK GY
IGN DROPOUT
WIF SENSOR
DRV HTR LOW
DRV HTR HI
AMMETER/ALT
P8
FRAME COMPONENTS
1710C LT BL 18 GA
1179B BK 16 GA
1212G WH 12GA
1744 LT BL 18 GA
ABS WARNING (-)
REV MOTION SEN (OPT)
CHASSIS GND
ABS SENSOR
AIR ABS SENSOR
1162H PK/BK 18GA
1008C PU 18 GA
1310A RD 18 GA
1322 LT BL 16 GA
NEUTRAL
IGN
REMOTE START
BRAKE SIGNAL(+)
BACKUP LGTS
2432 GN 16GA
1510 TN/BR 18 GA
CNG FUEL LEVEL
REV MOT SEN (OPT)
NEUTRAL/PARK/IN IDLE SIG
CNG FUEL LEVEL
1206P WH 14 GA
1113366 BK 16 GA
ELECTRONIC GRD
IGN ELECTRONIC POWER
1212Z WH 18 GA
1212AA WH 18 GA
1212BB WH 18 GA
1333J LT BL 18 GA
1166F PK/BK 16 GA
1166H PK/BK 16GA
AIR SEAT GRD
ILLUMINATION
GRD
ILLUMINATION
IGN
AIR SEAT IGN
GROUND
IGNITION DROPOUT
1212PP WH 18 GA
1168JJ PK/BK 16GA
P21
OPTION CONNECTOR



Master Chassis, CNG

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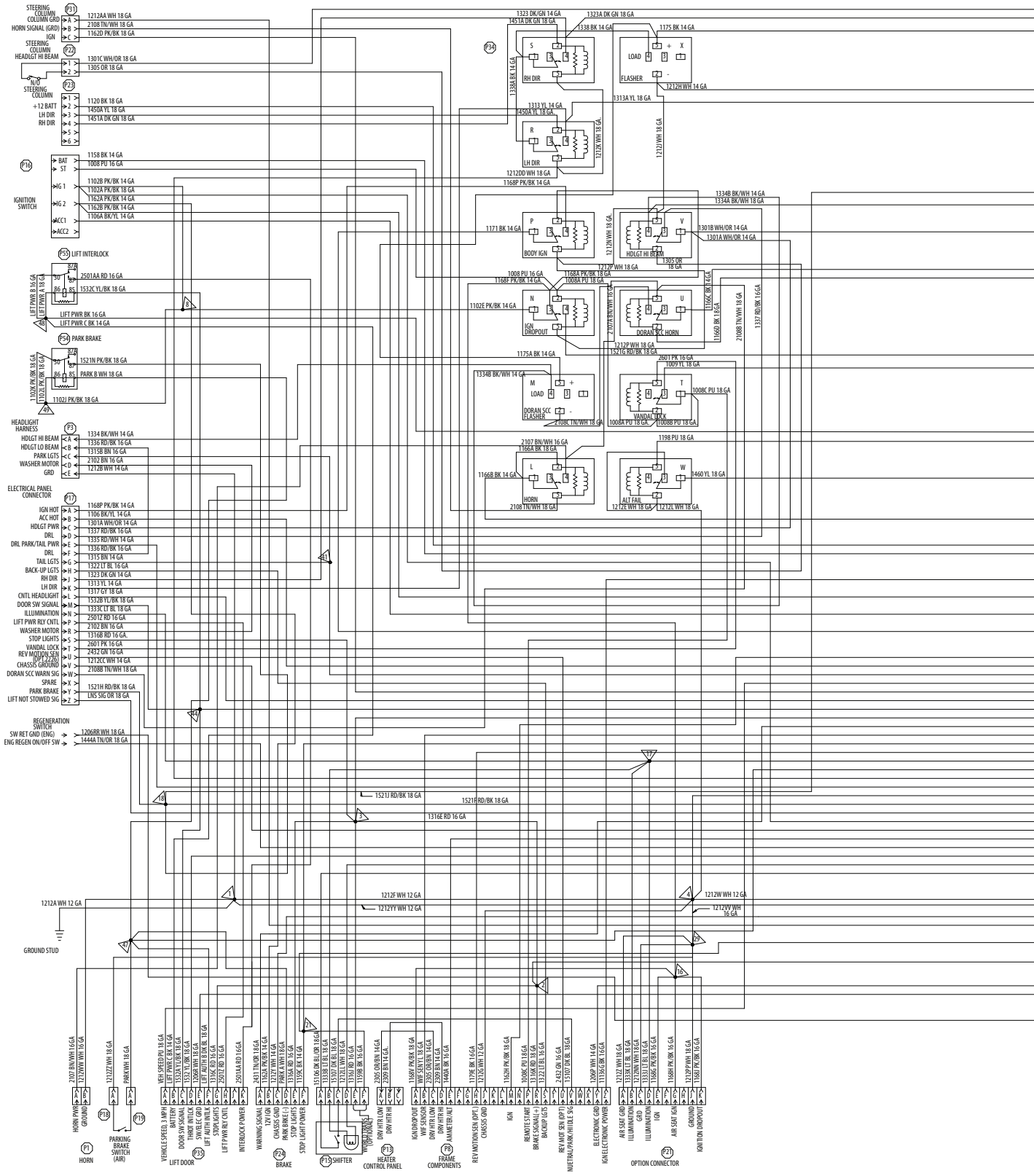
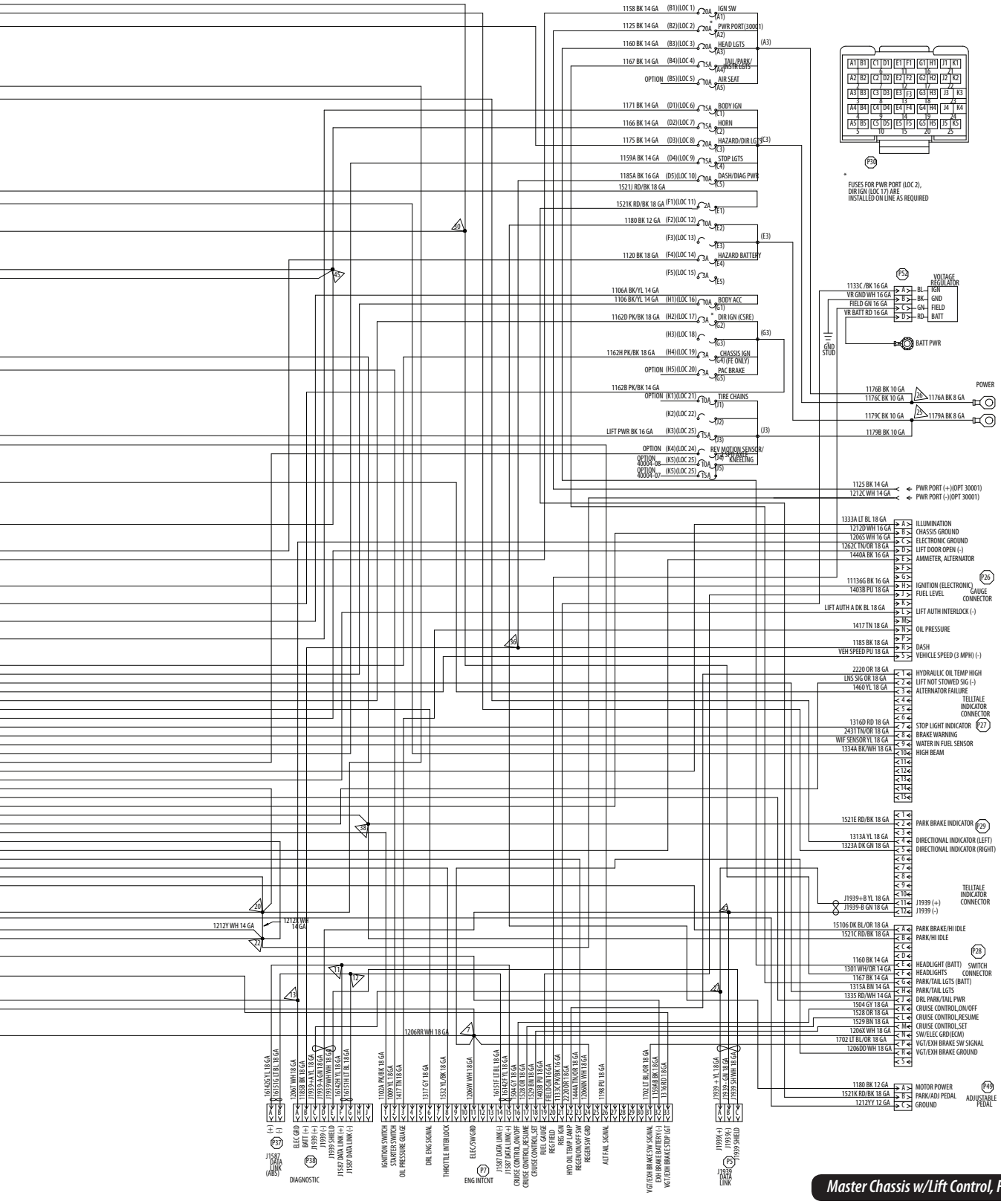

STEERING COLUMN
COLUMN GRD
HORN SIGNAL (GRD)
IGN
STEERING COLUMN
HEADLGT HI BEAM
N/O STEERING COLUMN
+12 BATT
LH DIR
RH DIR
IGNITION SWITCH
BAT
ST
IG 1
IG 2
ACC1
ACC2
LIFT INTERLOCK
LIFT PWR B 16 GA
LIFT PWR A 18 GA
LIFT PWR BK 16 GA
LIFT PWR C BK 14 GA
PARK BRAKE
HEADLIGHT HARNESS
HDLGT HI BEAM
HDLGT LO BEAM
PARK LGTS
WASHER MOTOR
GRD
ELECTRICAL PANEL CONNECTOR
IGN HOT
ACC HOT
HDLGT PWR
DRL
DRL PARK/TAIL PWR
TAIL LGTS
BACK-UP LGTS
CNTL HEADLIGHT
DOOR SW SIGNAL
ILLUMINATION
LIFT PWR RLY CNTL
WASHER MOTOR
STOP LIGHTS
VANDAL LOCK
REV MOTION SEN (OPT 2220)
CHASSIS GROUND
DORAN SCC WARN SIG
SPARE
PARK BRAKE
LIFT NOT STOWED SIG
REGENERATION SWITCH
SW RET GND (ENG)
ENG REGEN ON/OFF SW
GROUND STUD
HORN
PARKING BRAKE SWITCH (AIR)
LIFT DOOR
BRAKE
SHIFTER
HEATER CONTROL PANEL
FRAME COMPONENTS
OPTION CONNECTOR
RH DIR
LH DIR
LOAD
FLASHER
BODY IGN
HDLGT HI BEAM
IGN DROPOUT
DORAN SCC HORN
VANDAL LOCK
HORN
ALT FAIL



Master Chassis w/Lift Control, FE

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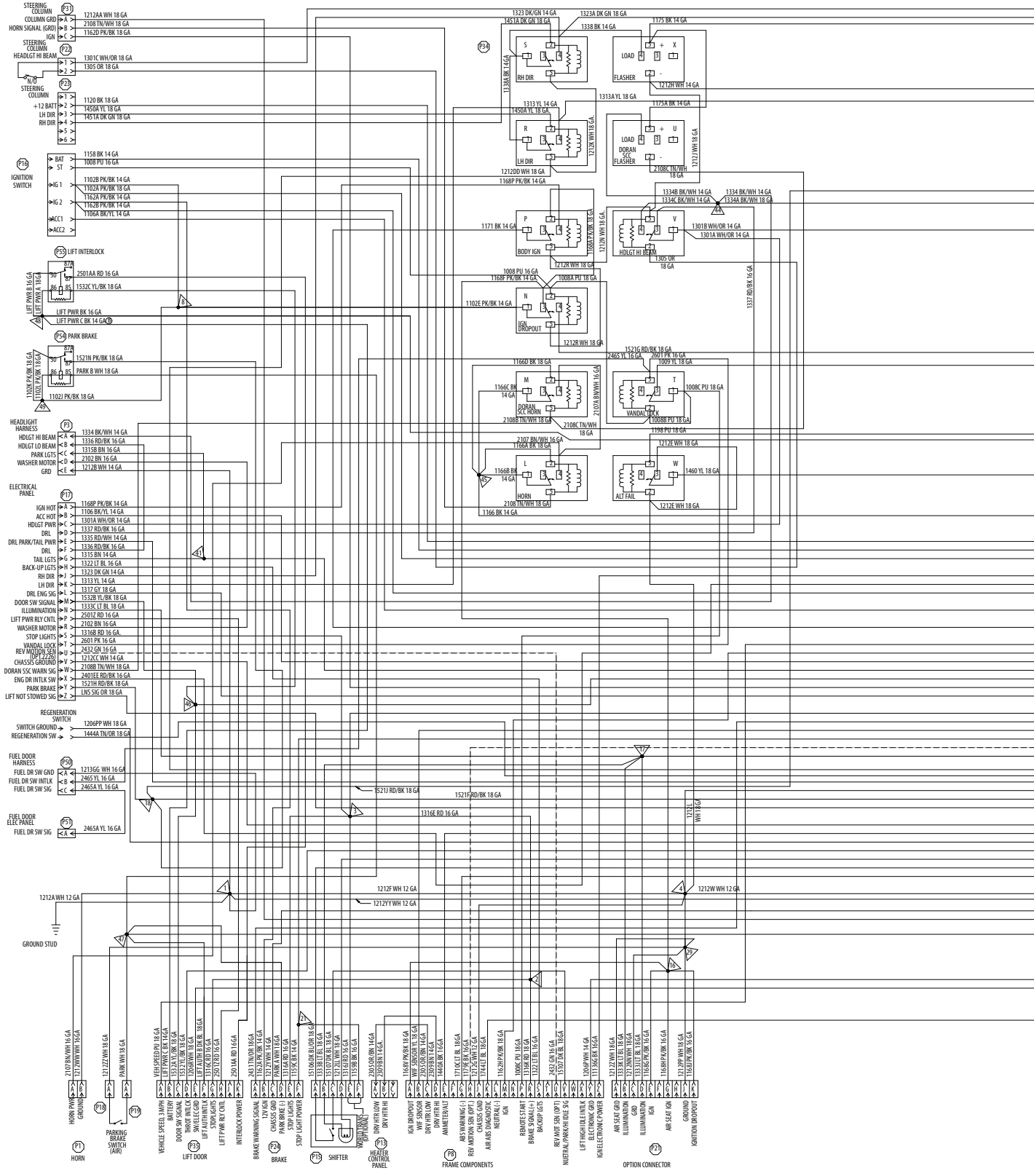
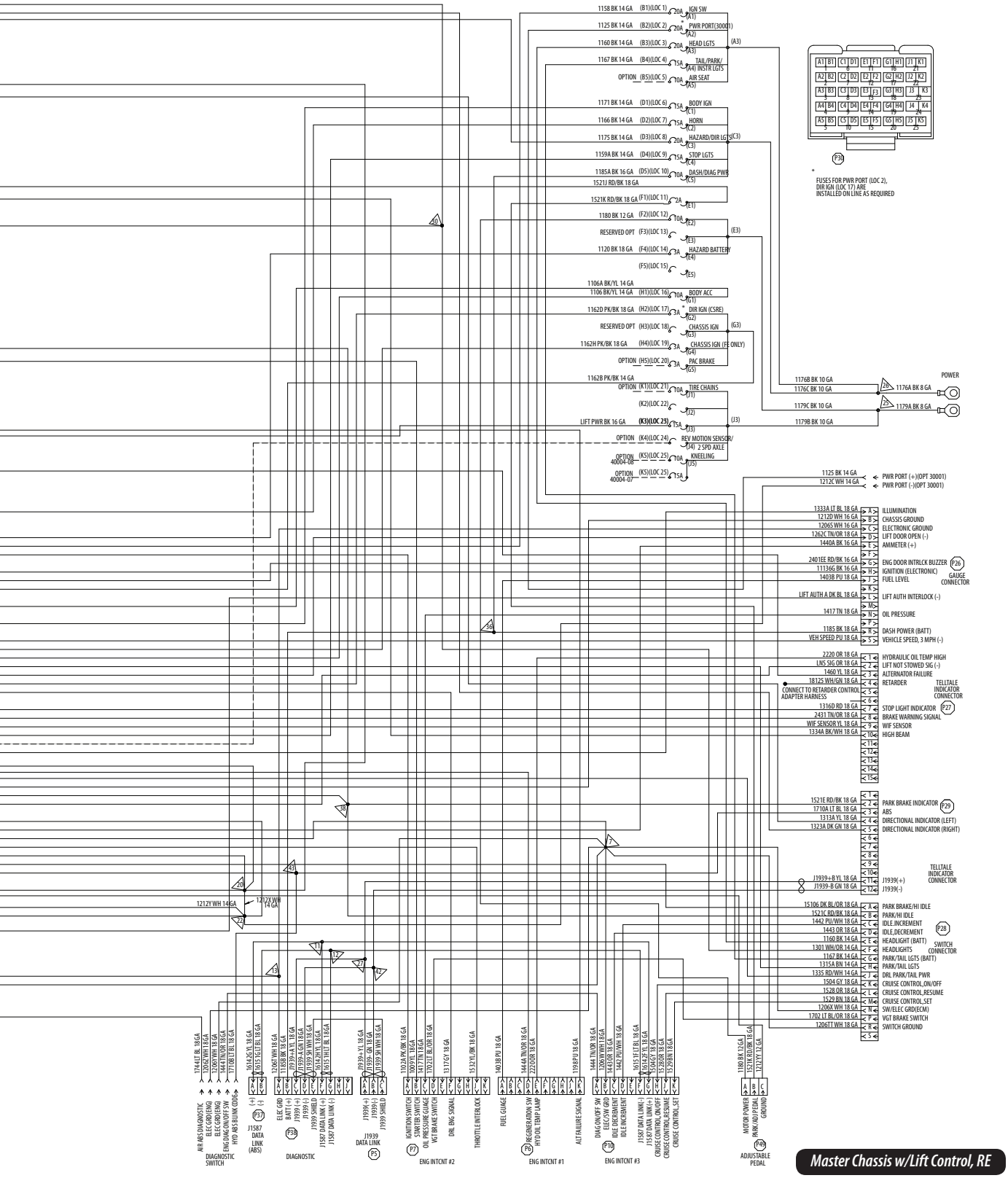

STEERING COLUMN
P31
COLUMN GRD
HORN SIGNAL (GRD)
IGN
1212AA WH 18 GA
2108 TN/WH 18 GA
1162D PK/BK 18 GA
STEERING COLUMN HEADLGT HI BEAM
P22
1301C WH/OR 18 GA
1305 OR 18 GA
N/O
STEERING COLUMN
P23
+12 BATT
LH DIR
RH DIR
1120 BK 18 GA
1450A YL 18 GA
1451A DK GN 18 GA
IGNITION SWITCH
P18
BAT
ST
IG 1
IG 2
ACC1
ACC2
1158 BK 14 GA
1008 PU 16 GA
1102B PK/BK 14 GA
1102A PK/BK 18 GA
1162A PK/BK 14 GA
1162B PK/BK 14 GA
1106A BK/YL 14 GA
P55 LIFT INTERLOCK
87A
30
87
86
85
2501AA RD 16 GA
1532C YL/BK 18 GA
LIFT PWR B 16 GA
LIFT PWR A 18 GA
LIFT PWR BK 16 GA
LIFT PWR C BK 14 GA
P56 PARK BRAKE
1521N PK/BK 18 GA
PARK B WH 18 GA
1102K PK/WH 18 GA
1102L PK/WH 18 GA
1102J PK/BK 18 GA
HEADLIGHT HARNESS
P3
HDLGT HI BEAM
HDLGT LO BEAM
PARK LGTS
WASHER MOTOR
GRD
1334 BK/WH 14 GA
1336 RD/BK 16 GA
1315B BN 16 GA
2102 BN 16 GA
1212B WH 14 GA
ELECTRICAL PANEL
P17
IGN HOT
ACC HOT
HDLGT PWR
DRL
DRL PARK/TAIL PWR
DRL
TAIL LGTS
BACK-UP LGTS
RH DIR
LH DIR
DRL ENG SIG
DOOR SW SIGNAL
ILLUMINATION
LIFT PWR RLY CNTL
WASHER MOTOR
STOP LIGHTS
VANDAL LOCK
REV MOTION SEN (OPT 22.8K)
CHASSIS GROUND
DORAN SSC WARN SIG
ENG DR INTLK SW
PARK BRAKE
LIFT NOT STOWED SIG
1168P PK/BK 14 GA
1106 BK/YL 14 GA
1301A WH/OR 14 GA
1337 RD/BK 16 GA
1335 RD/WH 14 GA
1336 RD/BK 16 GA
1315 BN 14 GA
1322 LT BL 16 GA
1323 DK GN 14 GA
1313 YL 14 GA
1317 GY 18 GA
1532B YL/BK 18 GA
1333C LT BL 18 GA
2501Z RD 16 GA
2102 BN 16 GA
1316B RD 16 GA.
2601 PK 16 GA
2432 GN 16 GA
1212CC WH 14 GA
2108B TN/WH 18 GA
2401EE RD/BK 16 GA
1521H RD/BK 18 GA
LNS SIG OR 18 GA
REGENERATION SWITCH
SWITCH GROUND
REGENERATION SW
1206PP WH 18 GA
1444A TN/OR 18 GA
FUEL DOOR HARNESS
P50
FUEL DR SW GND
FUEL DR SW INTLK
FUEL DR SW SIG
1213GG WH 16 GA
2465 YL 16 GA
2465A YL 16 GA
FUEL DOOR ELEC PANEL
P51
FUEL DR SW SIG
2465A YL 16 GA
1212A WH 12 GA
GROUND STUD
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
1521J RD/BK 18 GA
1521F RD/BK 18 GA
1316E RD 16 GA
1212J WH 16 GA
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1175 BK 14 GA
P34
S
RH DIR
LOAD
FLASHER
1212H WH 14 GA
1338A BK 14GA
1313A YL 18 GA
1313 YL 14 GA
1450A YL 18 GA
1175A BK 14 GA
R
LH DIR
1212K WH 18 GA
DORAN SEC FLASHER
2108C TN/WH 18 GA
1212J WH 18 GA
1212DD WH 18 GA
1168P PK/BK 14 GA
1334B BK/WH 14 GA
1334C BK/WH 14 GA
1334 BK/WH 14 GA
1334A BK/WH 18 GA
44
1171 BK 14 GA
P
BODY IGN
1168KK PK/OR 18 GA
1212N WH 18 GA
1301B WH/OR 14 GA
1301A WH/OR 14 GA
HDLGT HI BEAM
1305 OR 18 GA
1212R WH 18 GA
1008 PU 16 GA
1168F PK/BK 14 GA
1008A PU 18 GA
1102E PK/BK 14 GA
N
IGN DROPOUT
1212R WH 18 GA
1337 RD/BK 16 GA
1521G RD/BK 18 GA
2465 YL 16 GA
2601 PK 16 GA
1009 YL 18 GA
1166D BK 18 GA
M
1166C BK 14 GA
DORAN SCC HORN
2107 BN/WH 16 GA
2107 LB/WH 16 GA
T
1008C PU 18 GA
VANDAL LOCK
2108B TN/WH 18 GA
2108C TN/WH 18 GA
1008B PU 18 GA
1198 PU 18 GA
1212E WH 18 GA
1166A BK 18 GA
L
1166B BK 14 GA
45
HORN
2108 TN/WH 18 GA
W
1460 YL 18 GA
ALT FAIL
1212E WH 18 GA
1166 BK 14 GA
21 VIO/BN WH 16 GA
1212YW WH 16GA
HORN PWR
GROUND
P1
HORN
1212ZZ WH 18 GA
2468 WH 18 GA
P18
P19
PARKING BRAKE SWITCH (AIR)
VEH SPEED, 3 MPH
BATTERY
DOOR SW SIGNAL
THROT INTLK
SW ELEC GRD
LIFT AUTH INTLK
STOP LIGHTS
LIFT PWR RLY CNTL
INTERLOCK POWER
P35
LIFT DOOR
1532A YL 18 GA
1532 YL/BK 18 GA
1206BB WH 18 GA
1316C RD 18 GA
1316E RD 16 GA
2501AA RD 16 GA
2501AD RD 16 GA
1443 TN/OR 18GA
1763 LB/BK 18GA
BRAKE WARNING SIGNAL
12V IGN
CHASSIS GND
PARK BRAKE (-)
STOP LIGHT SW
STRP LIGHT POWER
1212 YW 14 GA
1316A RD 16 GA
1315K BK 14 GA
P24
BRAKE
1510K BK/OR 18 GA
1333B LT BL 18 GA
1510TJ BK 18 GA
1212EL WH 18 GA
1316B RD 16 GA
1515R BK 16 GA
P15
SHIFTER
2205 OR/BN 14 GA
2209 BN 14GA.
2209 BN 14 GA
1440A BK 16GA
HEATER CONTROL PANEL
P13
IGN DROPOUT
VHF SIGNSOR
DRV HTR LOW
DRV HTR HI
1168F PK/BK 18 GA
1206BB WH 18 GA
1206 BN 14 GA
2209 BN 14 GA
1440A BK 16GA
1771CC LT BL 18GA
1772BK YL 16GA
1772AA RD 16 GA
1774EL BL 18GA
ABS WARNING (-)
REV MOTION SEN (OPT)
CHASSIS GND
AIR ABS DIAGNOSTIC
NEUTRAL (-)
IGN
P8
FRAME COMPONENTS
1162H PK/OR 18 GA
1008E PU 18GA
1316A RD 18 GA
1212L YL 16 GA
REMOTE START
BRAKE SIGNAL (+)
BACKUP LGTS
2432 GN 16 GA
1510TJ BK 18 GA
REV MOTR SEN (OPT)
NEUTRAL/PARK/AIR IDLE SIG
1206PP WH 14 GA
LIFT HIGH IDLE INTLK
ELECTRONIC GRD
IGN ELECTRONIC POWER
1212ZZ WH 18GA
3333A LT BL 18 GA
1212NN WH 18GA
1212 YW 18 GA
1168KK PK/OR 16 GA
1168HH PK/OR 16 GA
AIR SEAT GRD
ILLUMINATION GRD
ILLUMINATION IGN
AIR SEAT IGN
1212PP WH 18 GA
1168T PK/OR 18 GA
GROUND
IGNITION DROPOUT
P21
OPTION CONNECTOR



Master Chassis w/Lift Control, RE

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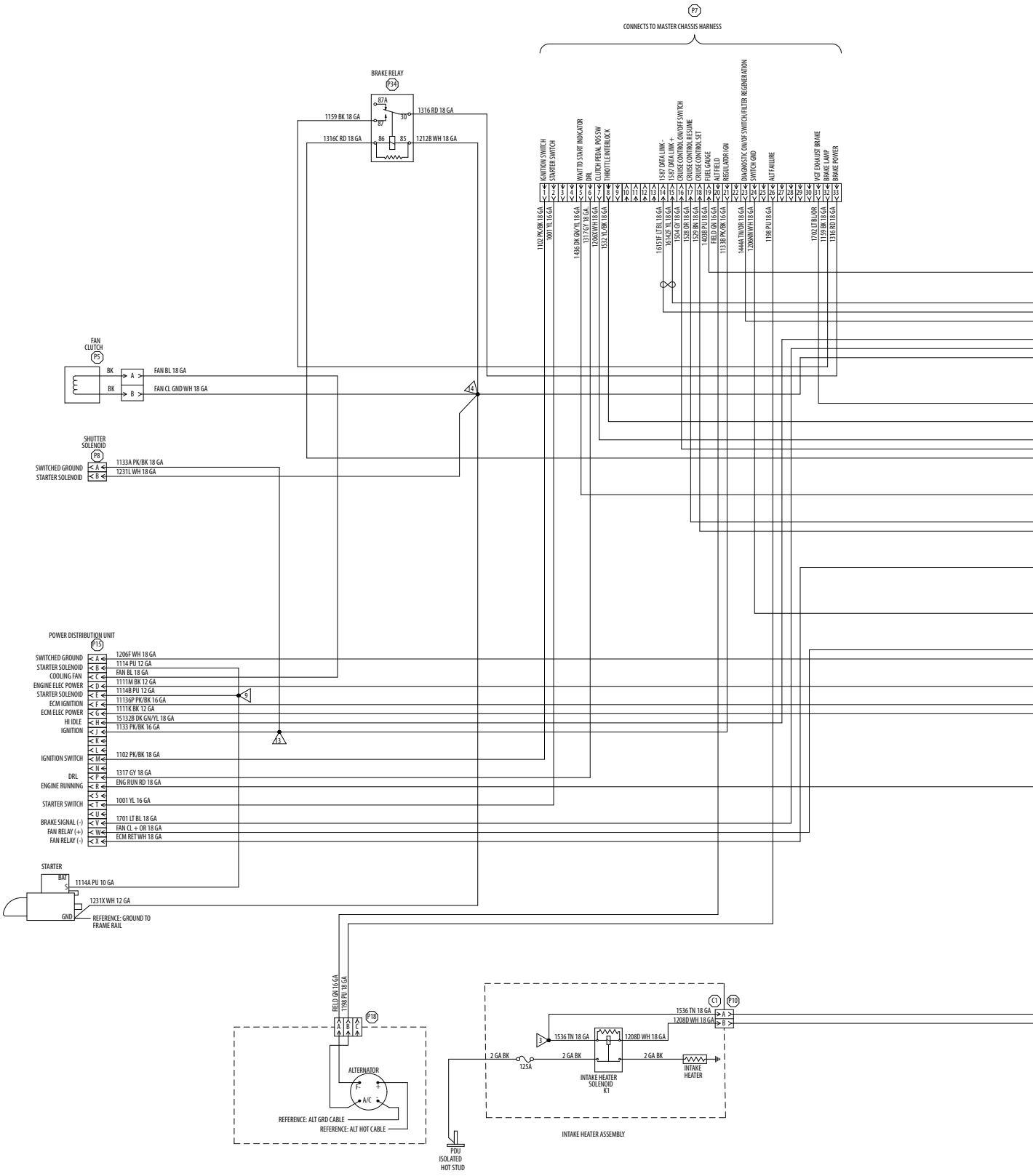
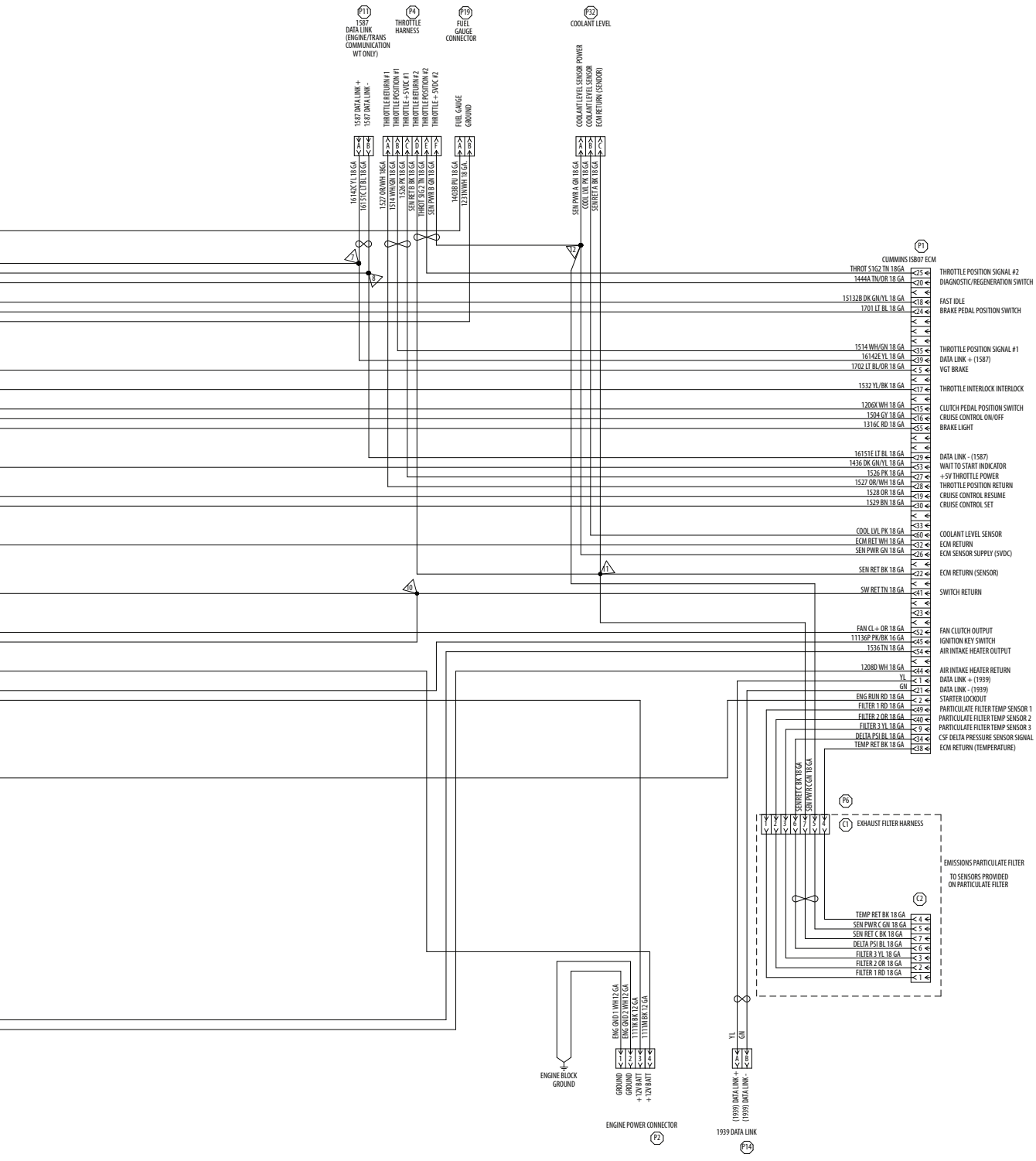

P7
CONNECTS TO MASTER CHASSIS HARNESS
BRAKE RELAY
P34
87A
87
30
85
86
1316 RD 18 GA
1159 BK 18 GA
1316C RD 18 GA
1212B WH 18 GA
IGNITION SWITCH
STARTER SWITCH
WAIT TO START INDICATOR
DRL
CLUTCH PEDAL POS SW
THROTTLE INTERLOCK
1587 DATA LINK -
1587 DATA LINK +
CRUISE CONTROL ON/OFF SWITCH
CRUISE CONTROL RESUME
CRUISE CONTROL SET
FUEL GAUGE
ALT FIELD
REGULATOR IGN
DIAGNOSTIC ON/OFF SWITCH/FILTER REGENERATION
SWITCH GND
ALT FAILURE
VGT EXHAUST BRAKE
BRAKE LAMP
BRAKE POWER
1102 PK/BK 18 GA
1001 YL 16 GA
1436 BK GN/YL 18 GA
1317 GY 18 GA
1206W WH 18 GA
1532 TL/BK 18 GA
1615 F-LT BL 18 GA
1614 LT BL 18 GA
1504 GY 18 GA
1529 OR 18 GA
1529 BK 18 GA
1403B PU 18 GA
FIELD GN 16 GA
113038 PK/BK 16 GA
14444 TN/OR 18 GA
1200WN WH 18 GA
1198 PU 18 GA
1702 LT BL/OR
1159 BK 18 GA
1316 RD 18 GA
FAN CLUTCH
P5
BK
A
B
FAN BL 18 GA
FAN CL GND WH 18 GA
14
SHUTTER SOLENOID
P8
SWITCHED GROUND
STARTER SOLENOID
1133A PK/BK 18 GA
1231L WH 18 GA
POWER DISTRIBUTION UNIT
P15
SWITCHED GROUND
STARTER SOLENOID
COOLING FAN
ENGINE ELEC POWER
STARTER SOLENOID
ECM IGNITION
ECM ELEC POWER
HI IDLE
IGNITION
IGNITION SWITCH
DRL
ENGINE RUNNING
STARTER SWITCH
BRAKE SIGNAL (-)
FAN RELAY (+)
FAN RELAY (-)
1206F WH 18 GA
1114 PU 12 GA
FAN BL 18 GA
1111M BK 12 GA
1114B PU 12 GA
1113GP PK/BK 16 GA
1111K BK 12 GA
15132B DK GN/YL 18 GA
1133 PK/BK 16 GA
1102 PK/BK 18 GA
1317 GY 18 GA
ENG RUN RD 18 GA
1001 YL 16 GA
1701 LT BL 18 GA
FAN CL + OR 18 GA
ECM RET WH 18 GA
9
13
STARTER
BAT
S
GND
1114A PU 10 GA
1231X WH 12 GA
REFERENCE: GROUND TO FRAME RAIL
FIELD GN 16 GA
1198 PU 18 GA
P18
A
B
C
ALTERNATOR
I+
B+
A/C
REFERENCE: ALT GRD CABLE
REFERENCE: ALT HOT CABLE
C1
P10
1536 TN 18 GA
1208D WH 18 GA
3
2 GA BK
125A
INTAKE HEATER SOLENOID K1
INTAKE HEATER
INTAKE HEATER ASSEMBLY
PDU ISOLATED HOT STUD



Engine, Cummins ISB-07, FE

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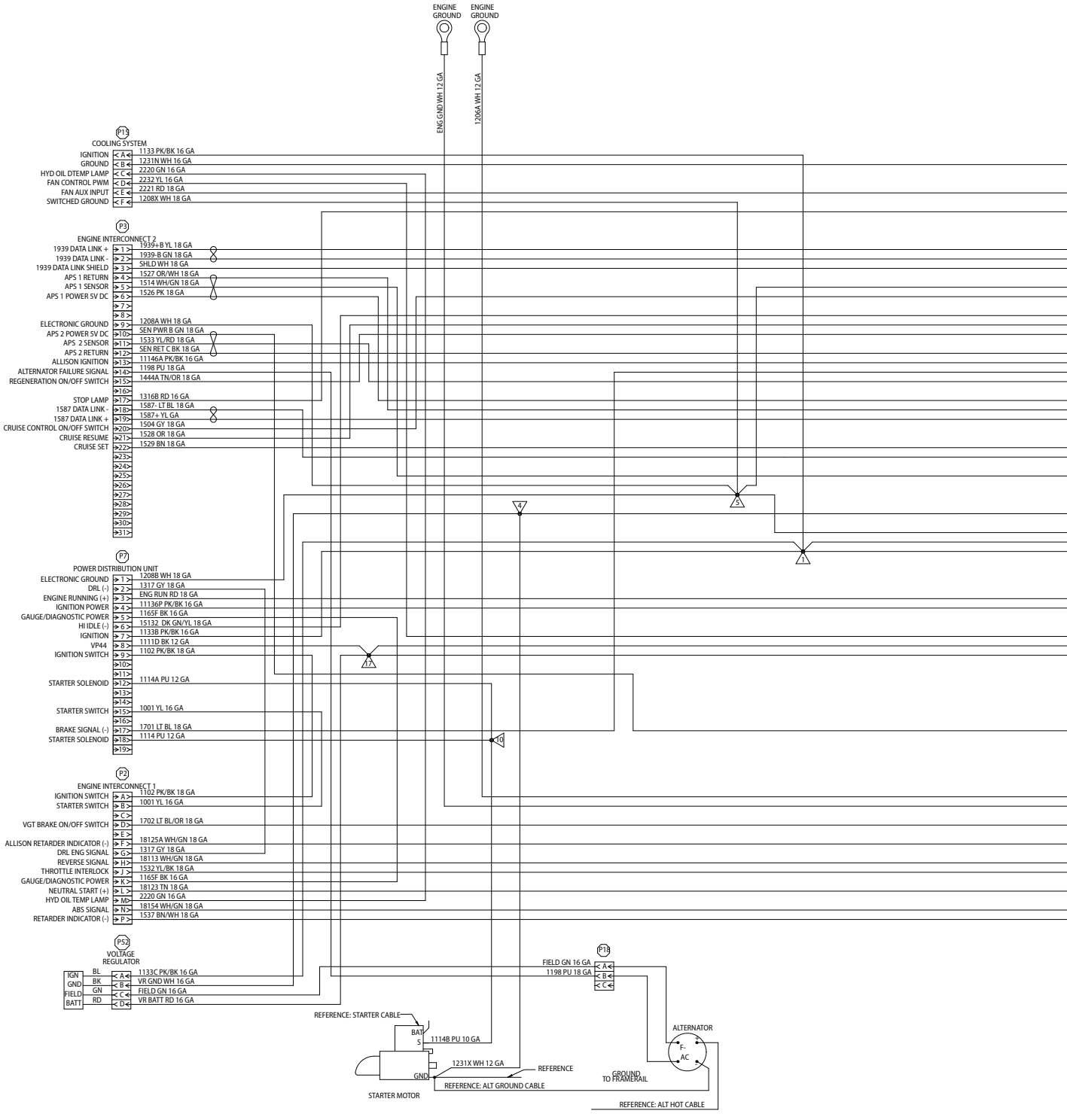
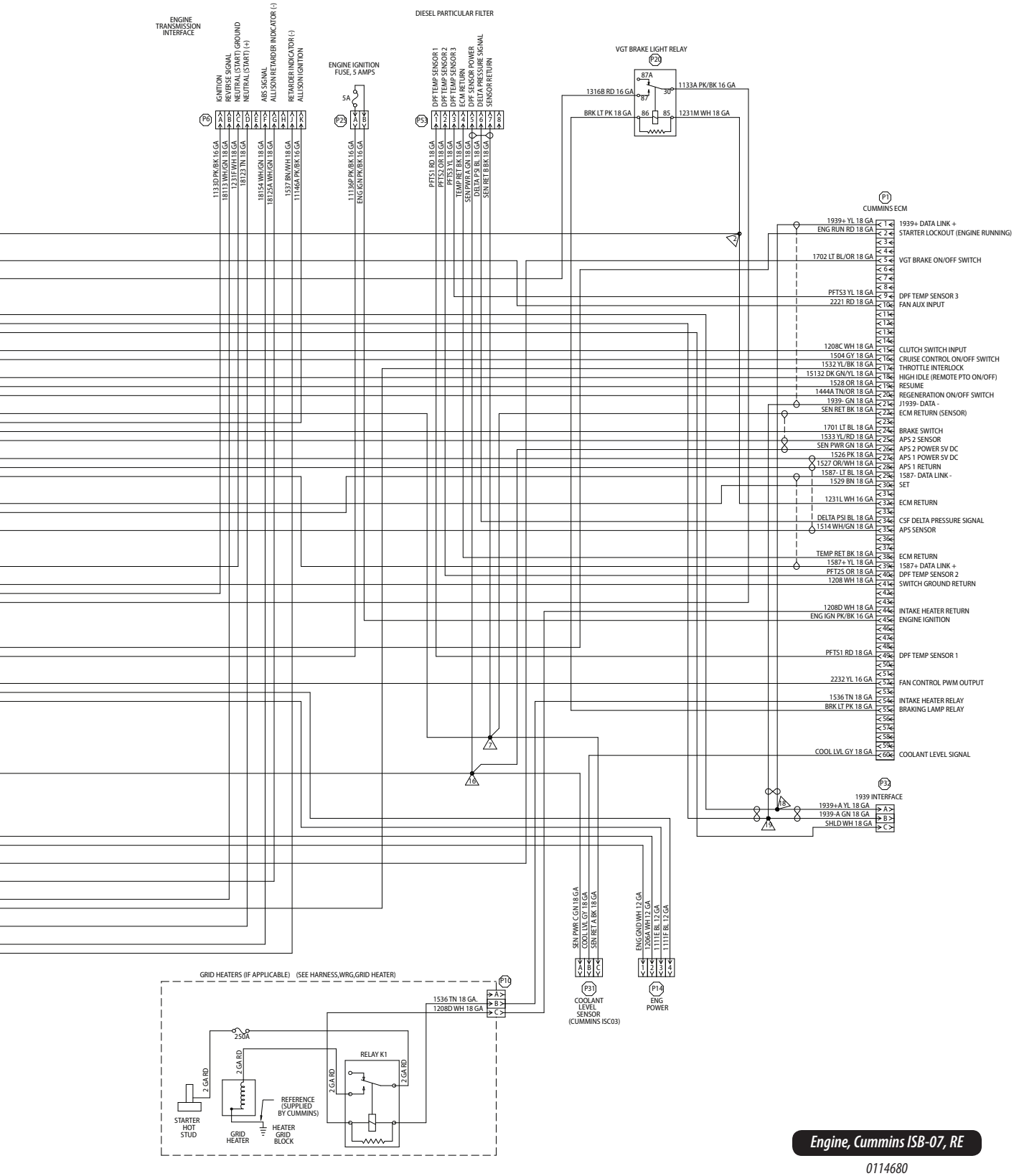

ENGINE GROUND
ENGINE GROUND
ENG GND WH 12 GA
1206A WH 12 GA
P13
COOLING SYSTEM
IGNITION 1133 PK/BK 16 GA
GROUND 1231N WH 16 GA
HYD OIL DTEMP LAMP 2220 GN 16 GA
FAN CONTROL PWM 2232 YL 16 GA
FAN AUX INPUT 2221 RD 18 GA
SWITCHED GROUND 1208X WH 18 GA
P3
ENGINE INTERCONNECT 2
1939 DATA LINK + 1939+B YL 18 GA
1939 DATA LINK - 1939-B GN 18 GA
1939 DATA LINK SHIELD SHLD WH 18 GA
APS 1 RETURN 1527 OR/WH 18 GA
APS 1 SENSOR 1514 WH/GN 18 GA
APS 1 POWER 5V DC 1526 PK 18 GA
ELECTRONIC GROUND 1208A WH 18 GA
APS 2 POWER 5V DC SEN PWR B GN 18 GA
APS 2 SENSOR 1533 YL/RD 18 GA
APS 2 RETURN SEN RET C BK 18 GA
ALLISON IGNITION 11146A PK/BK 16 GA
ALTERNATOR FAILURE SIGNAL 1198 PU 18 GA
REGENERATION ON/OFF SWITCH 1444A TN/OR 18 GA
STOP LAMP 1316B RD 16 GA
1587 DATA LINK - 1587- LT BL 18 GA
1587 DATA LINK + 1587+ YL GA
CRUISE CONTROL ON/OFF SWITCH 1504 GY 18 GA
CRUISE RESUME 1528 OR 18 GA
CRUISE SET 1529 BN 18 GA
P7
POWER DISTRIBUTION UNIT
ELECTRONIC GROUND 1208B WH 18 GA
DRL (-) 1317 GY 18 GA
ENGINE RUNNING (+) ENG RUN RD 18 GA
IGNITION POWER 11136P PK/BK 16 GA
GAUGE/DIAGNOSTIC POWER 1165F BK 16 GA
HI IDLE (-) 15132 DK GN/YL 18 GA
IGNITION 1133B PK/BK 16 GA
VP44 1111D BK 12 GA
IGNITION SWITCH 1102 PK/BK 18 GA
STARTER SOLENOID 1114A PU 12 GA
STARTER SWITCH 1001 YL 16 GA
BRAKE SIGNAL (-) 1701 LT BL 18 GA
STARTER SOLENOID 1114 PU 12 GA
P2
ENGINE INTERCONNECT 1
IGNITION SWITCH 1102 PK/BK 18 GA
STARTER SWITCH 1001 YL 16 GA
VGT BRAKE ON/OFF SWITCH 1702 LT BL/OR 18 GA
ALLISON RETARDER INDICATOR (-) 18125A WH/GN 18 GA
DRL ENG SIGNAL 1317 GY 18 GA
REVERSE SIGNAL 18113 WH/GN 18 GA
THROTTLE INTERLOCK 1532 YL/BK 18 GA
GAUGE/DIAGNOSTIC POWER 1165F BK 16 GA
NEUTRAL START (+) 18123 TN 18 GA
HYD OIL TEMP LAMP 2220 GN 16 GA
ABS SIGNAL 18154 WH/GN 18 GA
RETARDER INDICATOR (-) 1537 BN/WH 18 GA
P52
VOLTAGE REGULATOR
IGN BL 1133C PK/BK 16 GA
GND BK VR GND WH 16 GA
FIELD GN FIELD GN 16 GA
BATT RD VR BATT RD 16 GA
P18
FIELD GN 16 GA
1198 PU 18 GA
REFERENCE: STARTER CABLE
BAT
S
1114B PU 10 GA
1231X WH 12 GA
REFERENCE
GND
STARTER MOTOR
REFERENCE: ALT GROUND CABLE
ALTERNATOR
F-
AC
GROUND TO FRAME RAIL
REFERENCE: ALT HOT CABLE
4
5
1
17
10



Engine, Cummins ISB-07, RE

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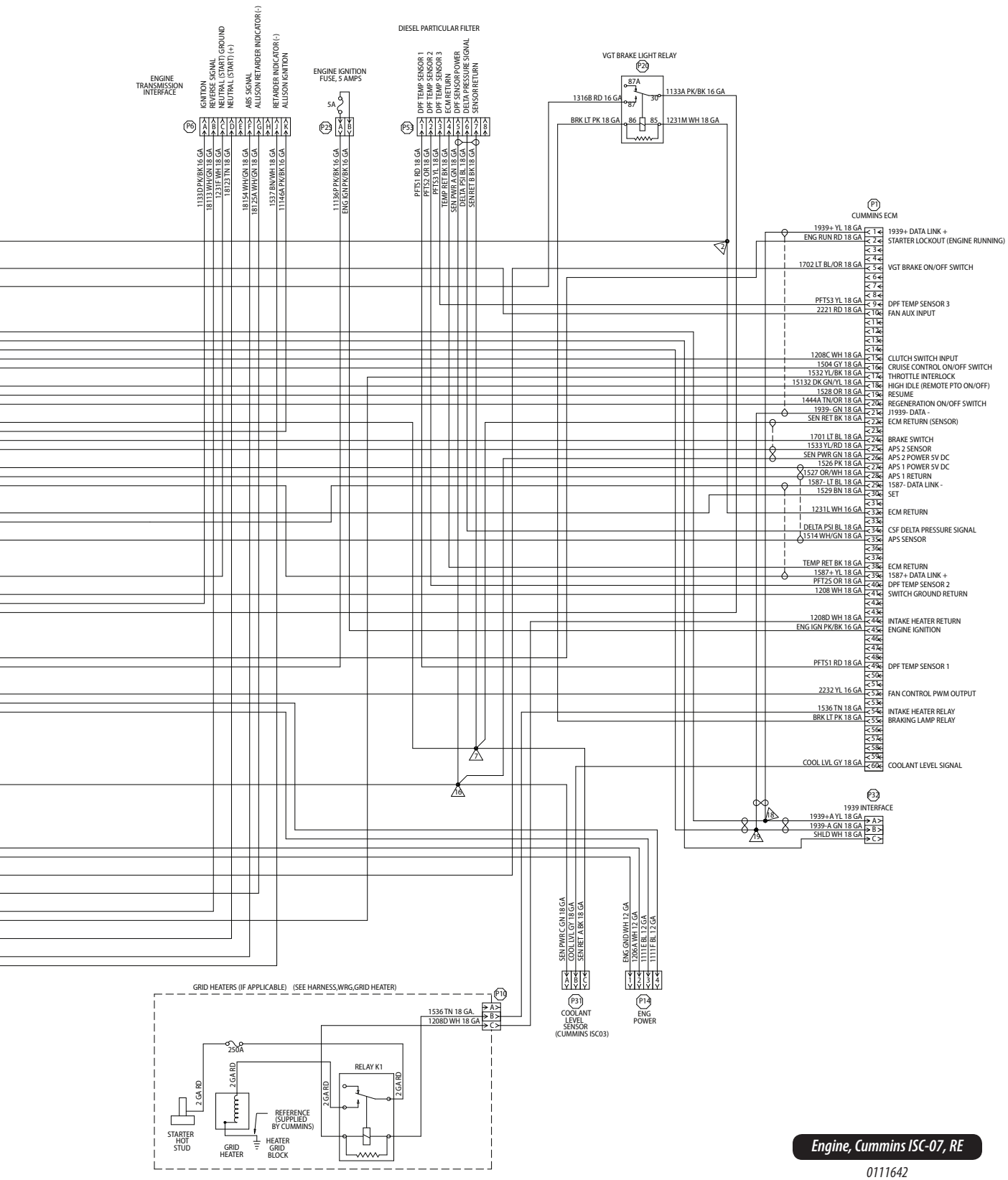
ENGINE GROUND
ENGINE GROUND
ENG GND WH 12 GA
1206A WH 12 GA
P13
COOLING SYSTEM
IGNITION < A < 1133 PK/BK 16 GA
GROUND < B < 1231N WH 16 GA
HYD OIL DTEMP LAMP < C < 2220 GN 16 GA
FAN CONTROL PWM < D < 2232 YL 16 GA
FAN AUX INPUT < E < 2221 RD 18 GA
SWITCHED GROUND < F < 1208X WH 18 GA
P3
ENGINE INTERCONNECT 2
1939 DATA LINK + > 1 > 1939+B YL 18 GA
1939 DATA LINK - > 2 > 1939-B GN 18 GA
1939 DATA LINK SHIELD > 3 > SHLD WH 18 GA
APS 1 RETURN > 4 > 1527 OR/WH 18 GA
APS 1 SENSOR > 5 > 1514 WH/GN 18 GA
APS 1 POWER 5V DC > 6 > 1526 PK 18 GA
> 7 >
> 8 > 1208A WH 18 GA
ELECTRONIC GROUND > 9 > SEN PWR B GN 18 GA
APS 2 POWER 5V DC > 10 > 1533 YL/RD 18 GA
APS 2 SENSOR > 11 > SEN RET C BK 18 GA
APS 2 RETURN > 12 > 11146A PK/BK 16 GA
ALLISON IGNITION > 13 > 1198 PU 18 GA
ALTERNATOR FAILURE SIGNAL > 14 > 1444A TN/OR 18 GA
REGENERATION ON/OFF SWITCH > 15 >
> 16 > 1316B RD 16 GA
STOP LAMP > 17 > 1587- LT BL 18 GA
1587 DATA LINK - > 18 > 1587+ YL GA
1587 DATA LINK + > 19 > 1504 GY 18 GA
CRUISE CONTROL ON/OFF SWITCH > 20 > 1528 OR 18 GA
CRUISE RESUME > 21 > 1529 BN 18 GA
CRUISE SET > 22 >
> 23 >
> 24 >
> 25 >
> 26 >
> 27 >
> 28 >
> 29 >
> 30 >
> 31 >
P7
POWER DISTRIBUTION UNIT
ELECTRONIC GROUND > 1 > 1208B WH 18 GA
DRL (-) > 2 > 1317 GY 18 GA
ENGINE RUNNING (+) > 3 > ENG RUN RD 18 GA
IGNITION POWER > 4 > 11136P PK/BK 16 GA
GAUGE/DIAGNOSTIC POWER > 5 > 1165F BK 16 GA
HI IDLE (-) > 6 > 15132 DK GN/YL 18 GA
IGNITION > 7 > 1133B PK/BK 16 GA
VP44 > 8 > 1111D BK 12 GA
IGNITION SWITCH > 9 > 1102 PK/BK 18 GA
> 10 >
> 11 >
STARTER SOLENOID > 12 > 1114A PU 12 GA
> 13 >
> 14 >
STARTER SWITCH > 15 > 1001 YL 16 GA
> 16 >
BRAKE SIGNAL (-) > 17 > 1701 LT BL 18 GA
STARTER SOLENOID > 18 > 1114 PU 12 GA
> 19 >
P2
ENGINE INTERCONNECT 1
IGNITION SWITCH > A > 1102 PK/BK 18 GA
STARTER SWITCH > B > 1001 YL 16 GA
> C >
VGT BRAKE ON/OFF SWITCH > D > 1702 LT BL/OR 18 GA
> E >
ALLISON RETARDER INDICATOR (-) > F > 18125A WH/GN 18 GA
DRL ENG SIGNAL > G > 1317 GY 18 GA
REVERSE SIGNAL > H > 18113 WH/GN 18 GA
THROTTLE INTERLOCK > J > 1532 YL/BK 18 GA
GAUGE/DIAGNOSTIC POWER > K > 1165F BK 16 GA
NEUTRAL START (+) > L > 18123 TN 18 GA
HYD OIL TEMP LAMP > M > 2220 GN 16 GA
ABS SIGNAL > N > 18154 WH/GN 18 GA
RETARDER INDICATOR (-) > P > 1537 BN/WH 18 GA
P52
VOLTAGE REGULATOR
IGN BL < A < 1133C PK/BK 16 GA
GND BK < B < VR GND WH 16 GA
FIELD GN < C < FIELD GN 16 GA
BATT RD < D < VR BATT RD 16 GA
P13
FIELD GN 16 GA
1198 PU 18 GA
< A <
< B <
< C <
REFERENCE: STARTER CABLE
BAT
S
1114B PU 10 GA
1231X WH 12 GA
REFERENCE
GND
REFERENCE: ALT GROUND CABLE
STARTER MOTOR
ALTERNATOR
F-
AC
GROUND TO FRAMERAIL
REFERENCE: ALT HOT CABLE
4
5
1
17
10



Engine, Cummins ISC-07, RE

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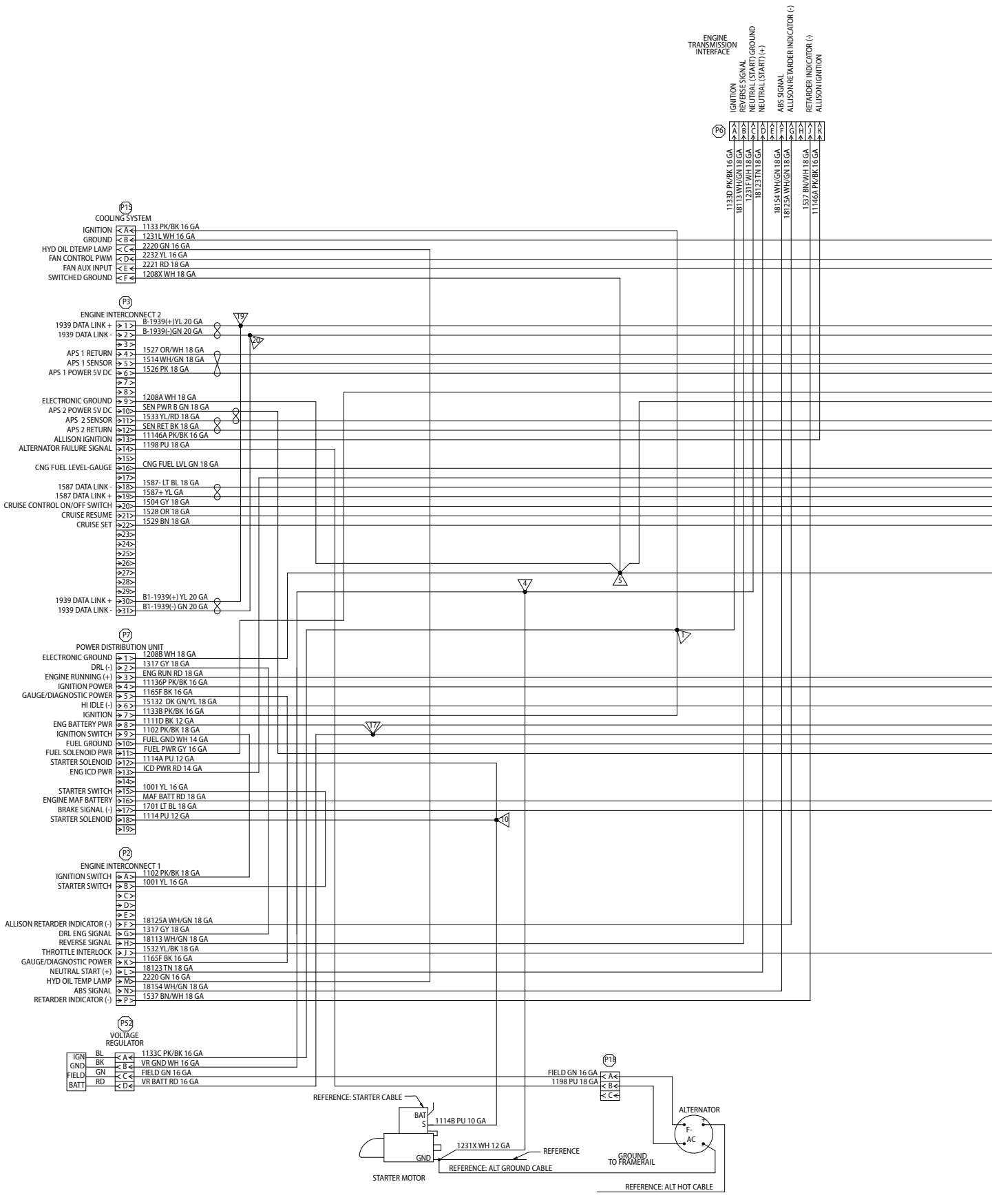
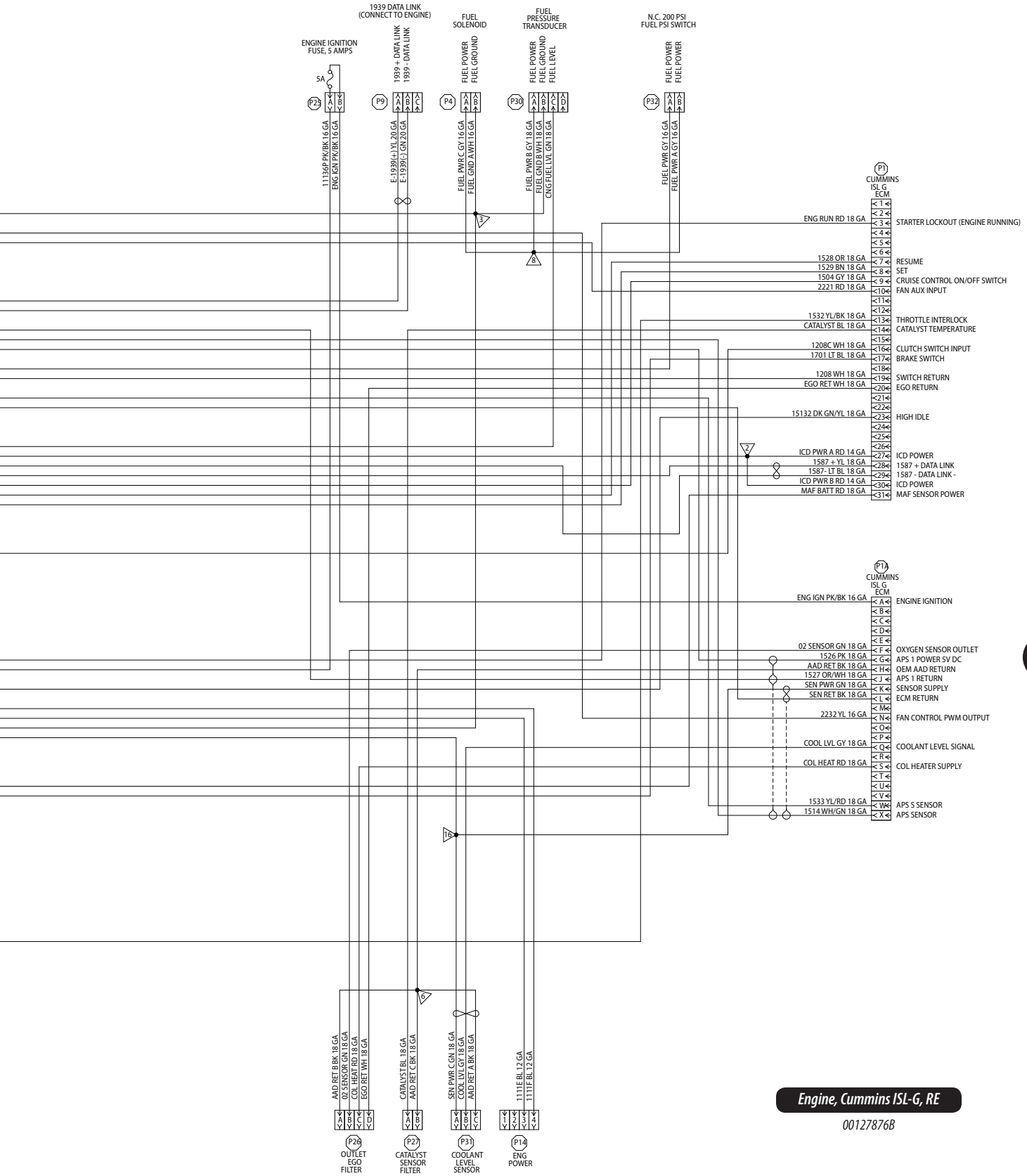

ENGINE TRANSMISSION INTERFACE
P6
IGNITION
REVERSE SIGNAL
NEUTRAL (START) GROUND
NEUTRAL (START) (+)
ABS SIGNAL
ALLISON RETARDER INDICATOR (-)
RETARDER INDICATOR (-) ALLISON IGNITION
1133D PK/BK 16 GA
18113 WH/GN 18 GA
1231F WH 18 GA
18123 TN 18 GA
18154 WH/GN 18 GA
18125A WH/GN 18 GA
1537 BN/WH 18 GA
11146A PK/BK 16 GA
P13
COOLING SYSTEM
IGNITION 1133 PK/BK 16 GA
GROUND 1231L WH 16 GA
HYD OIL DTEMP LAMP 2220 GN 16 GA
FAN CONTROL PWM 2232 YL 16 GA
FAN AUX INPUT 2221 RD 18 GA
SWITCHED GROUND 1208X WH 18 GA
P3
ENGINE INTERCONNECT 2
1939 DATA LINK + B-1939(+)YL 20 GA
1939 DATA LINK - B-1939(-)GN 20 GA
APS 1 RETURN 1527 OR/WH 18 GA
APS 1 SENSOR 1514 WH/GN 18 GA
APS 1 POWER 5V DC 1526 PK 18 GA
ELECTRONIC GROUND 1208A WH 18 GA
APS 2 POWER 5V DC SEN PWR B GN 18 GA
APS 2 SENSOR 1533 YL/RD 18 GA
APS 2 RETURN SEN RET BK 18 GA
ALLISON IGNITION 11146A PK/BK 16 GA
ALTERNATOR FAILURE SIGNAL 1198 PU 18 GA
CNG FUEL LEVEL-GAUGE CNG FUEL LVL GN 18 GA
1587 DATA LINK - 1587- LT BL 18 GA
1587 DATA LINK + 1587+ YL GA
CRUISE CONTROL ON/OFF SWITCH 1504 GY 18 GA
CRUISE RESUME 1528 OR 18 GA
CRUISE SET 1529 BN 18 GA
1939 DATA LINK + B1-1939(+) YL 20 GA
1939 DATA LINK - B1-1939(-) GN 20 GA
P7
POWER DISTRIBUTION UNIT
ELECTRONIC GROUND 1208B WH 18 GA
DRL (-) 1317 GY 18 GA
ENGINE RUNNING (+) ENG RUN RD 18 GA
IGNITION POWER 11136P PK/BK 16 GA
GAUGE/DIAGNOSTIC POWER 1165F BK 16 GA
HI IDLE (-) 15132 DK GN/YL 18 GA
IGNITION 1133B PK/BK 16 GA
ENG BATTERY PWR 1111D BK 12 GA
IGNITION SWITCH 1102 PK/BK 18 GA
FUEL GROUND FUEL GND WH 14 GA
FUEL SOLENOID PWR FUEL PWR GY 16 GA
STARTER SOLENOID 1114A PU 12 GA
ENG ICD PWR ICD PWR RD 14 GA
STARTER SWITCH 1001 YL 16 GA
ENGINE MAF BATTERY MAF BATT RD 18 GA
BRAKE SIGNAL (-) 1701 LT BL 18 GA
STARTER SOLENOID 1114 PU 12 GA
P2
ENGINE INTERCONNECT 1
IGNITION SWITCH 1102 PK/BK 18 GA
STARTER SWITCH 1001 YL 16 GA
ALLISON RETARDER INDICATOR (-) 18125A WH/GN 18 GA
DRL ENG SIGNAL 1317 GY 18 GA
REVERSE SIGNAL 18113 WH/GN 18 GA
THROTTLE INTERLOCK 1532 YL/BK 18 GA
GAUGE/DIAGNOSTIC POWER 1165F BK 16 GA
NEUTRAL START (+) 18123 TN 18 GA
HYD OIL TEMP LAMP 2220 GN 16 GA
ABS SIGNAL 18154 WH/GN 18 GA
RETARDER INDICATOR (-) 1537 BN/WH 18 GA
PS2
VOLTAGE REGULATOR
IGN BL 1133C PK/BK 16 GA
GND BK VR GND WH 16 GA
FIELD GN FIELD GN 16 GA
BATT RD VR BATT RD 16 GA
P18
FIELD GN 16 GA
1198 PU 18 GA
REFERENCE: STARTER CABLE
BAT
S
1114B PU 10 GA
1231X WH 12 GA
GND
REFERENCE
STARTER MOTOR
ALTERNATOR
F-
AC
GROUND TO FRAMERAIL
REFERENCE: ALT GROUND CABLE
REFERENCE: ALT HOT CABLE



Engine, Cummins ISL-G, RE

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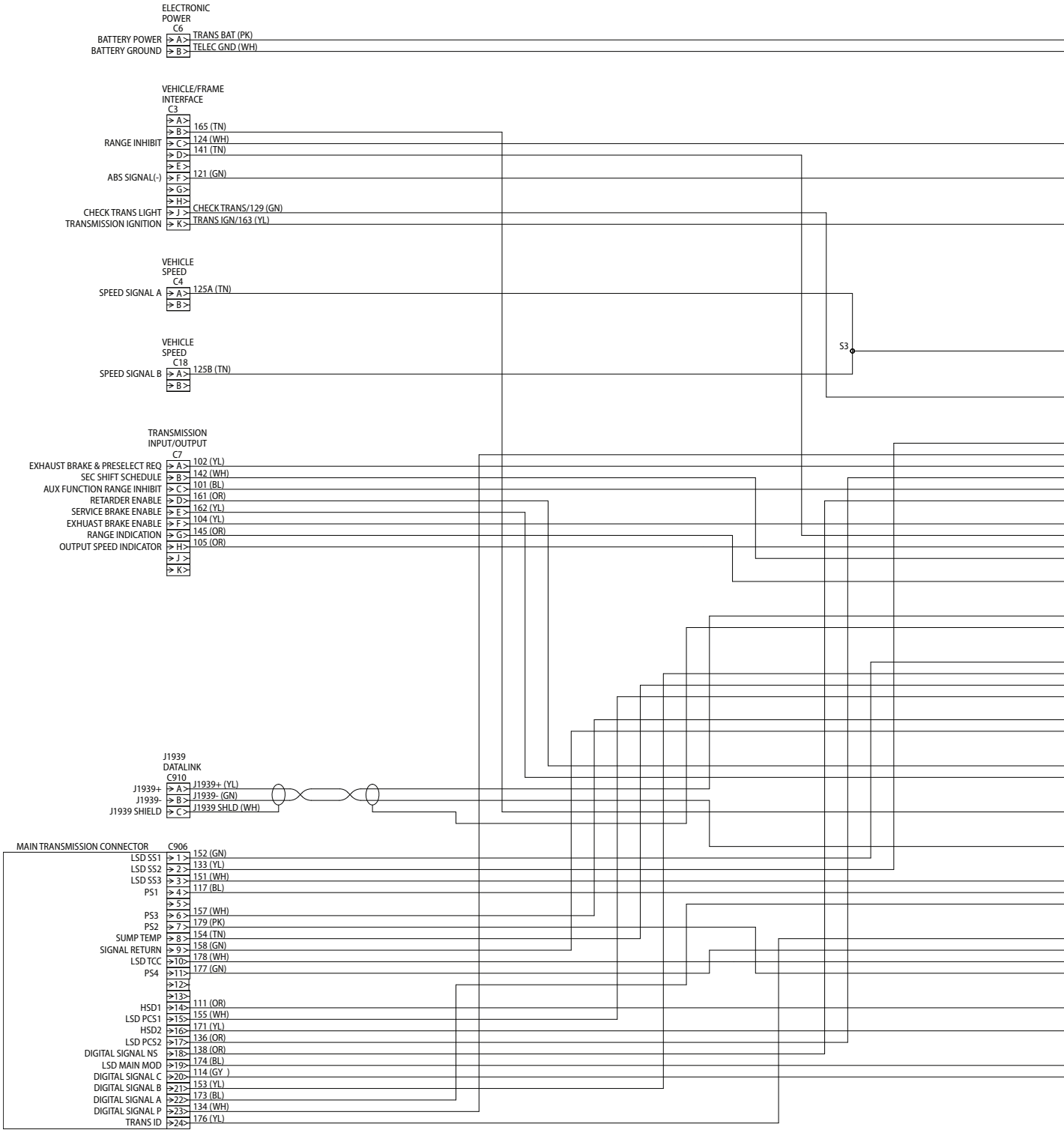
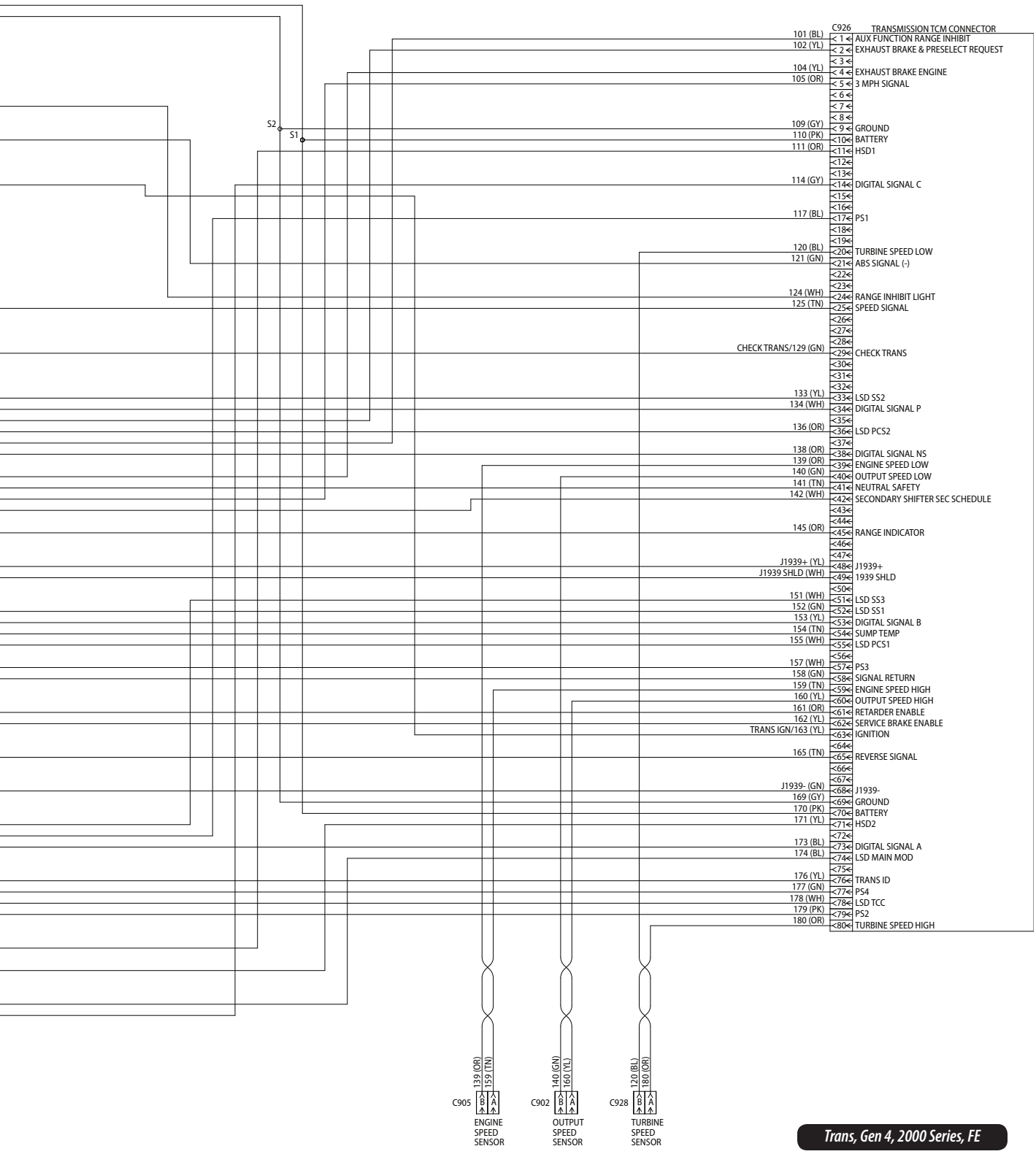

ELECTRONIC POWER
C6
BATTERY POWER
BATTERY GROUND
A
B
TRANS BAT (PK)
TELEC GND (WH)
VEHICLE/FRAME INTERFACE
C3
RANGE INHIBIT
ABS SIGNAL(-)
CHECK TRANS LIGHT
TRANSMISSION IGNITION
165 (TN)
124 (WH)
141 (TN)
121 (GN)
CHECK TRANS/129 (GN)
TRANS IGN/163 (YL)
VEHICLE SPEED
C4
SPEED SIGNAL A
125A (TN)
VEHICLE SPEED
C18
SPEED SIGNAL B
125B (TN)
S3
TRANSMISSION INPUT/OUTPUT
C7
EXHAUST BRAKE & PRESELECT REQ
SEC SHIFT SCHEDULE
AUX FUNCTION RANGE INHIBIT
RETARDER ENABLE
SERVICE BRAKE ENABLE
EXHUAST BRAKE ENABLE
RANGE INDICATION
OUTPUT SPEED INDICATOR
102 (YL)
142 (WH)
101 (BL)
161 (OR)
162 (YL)
104 (YL)
145 (OR)
105 (OR)
J1939 DATALINK
C910
J1939+
J1939-
J1939 SHIELD
J1939+ (YL)
J1939- (GN)
J1939 SHLD (WH)
MAIN TRANSMISSION CONNECTOR
C906
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
152 (GN)
133 (YL)
151 (WH)
117 (BL)
157 (WH)
179 (PK)
154 (TN)
158 (GN)
178 (WH)
177 (GN)
111 (OR)
155 (WH)
171 (YL)
136 (OR)
138 (OR)
174 (BL)
114 (GY)
153 (YL)
173 (BL)
134 (WH)
176 (YL)



Trans, Gen 4, 2000 Series, FE

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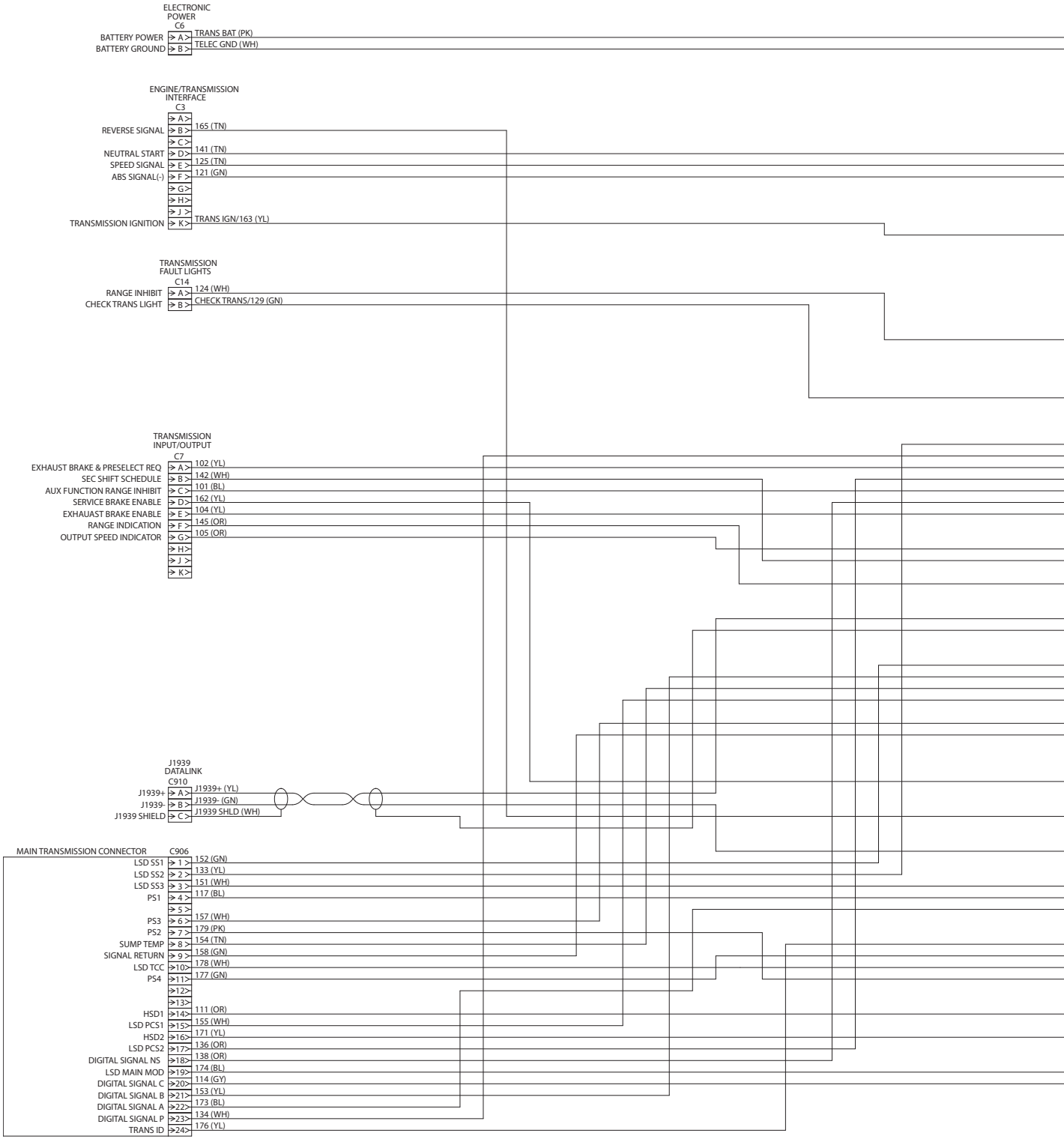
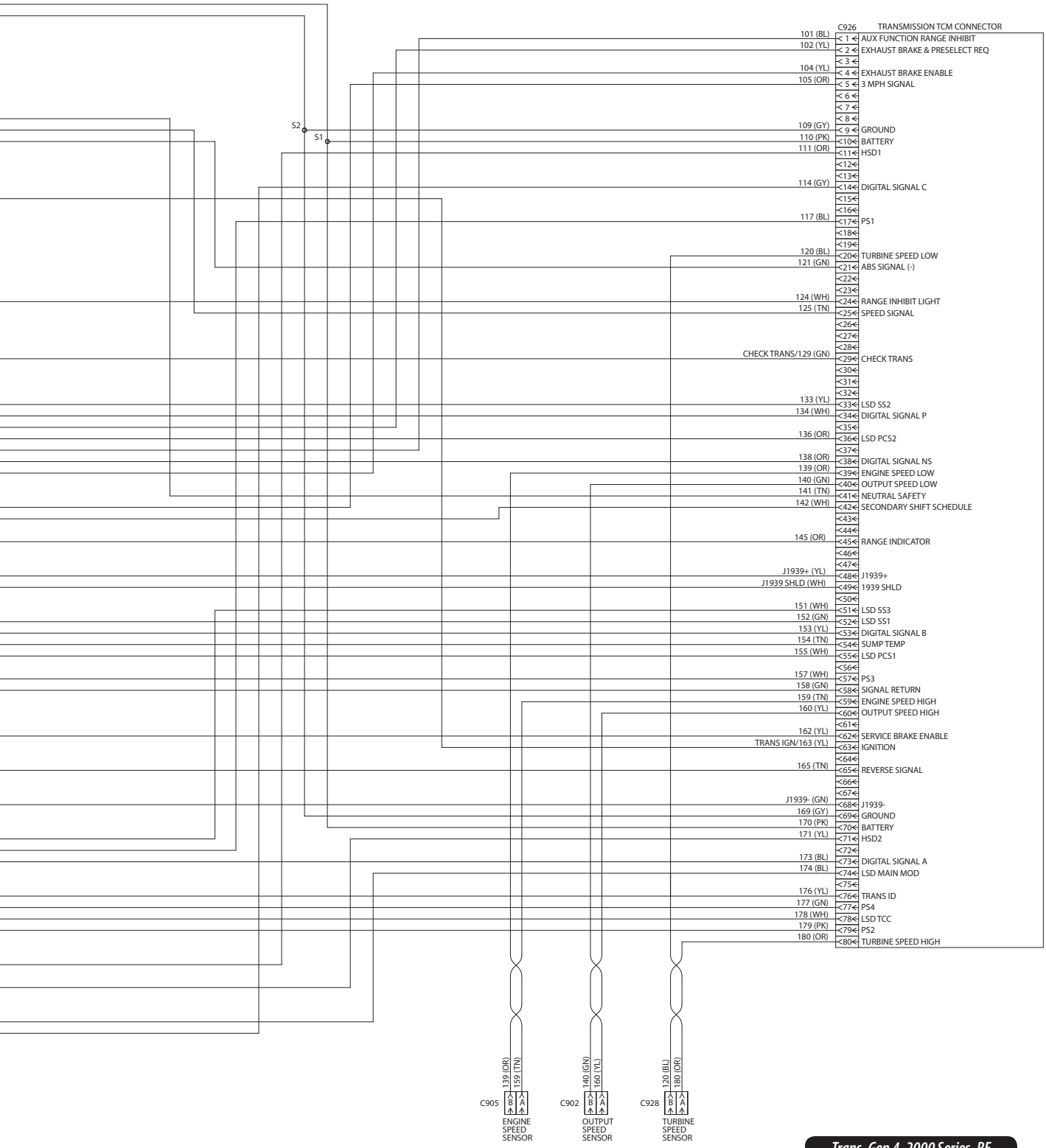

ELECTRONIC POWER
C6
BATTERY POWER
BATTERY GROUND
A
B
TRANS BAT (PK)
TELEC GND (WH)
ENGINE/TRANSMISSION INTERFACE
C3
REVERSE SIGNAL
NEUTRAL START
SPEED SIGNAL
ABS SIGNAL(-)
TRANSMISSION IGNITION
165 (TN)
141 (TN)
125 (TN)
121 (GN)
TRANS IGN/163 (YL)
TRANSMISSION FAULT LIGHTS
C14
RANGE INHIBIT
CHECK TRANS LIGHT
124 (WH)
CHECK TRANS/129 (GN)
TRANSMISSION INPUT/OUTPUT
C7
EXHAUST BRAKE & PRESELECT REQ
SEC SHIFT SCHEDULE
AUX FUNCTION RANGE INHIBIT
SERVICE BRAKE ENABLE
EXHAUAST BRAKE ENABLE
RANGE INDICATION
OUTPUT SPEED INDICATOR
102 (YL)
142 (WH)
101 (BL)
162 (YL)
104 (YL)
145 (OR)
105 (OR)
J1939 DATALINK
C910
J1939+
J1939-
J1939 SHIELD
J1939+ (YL)
J1939- (GN)
J1939 SHLD (WH)
MAIN TRANSMISSION CONNECTOR
C906
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
152 (GN)
133 (YL)
151 (WH)
117 (BL)
157 (WH)
179 (PK)
154 (TN)
158 (GN)
178 (WH)
177 (GN)
111 (OR)
155 (WH)
171 (YL)
136 (OR)
138 (OR)
174 (BL)
114 (GY)
153 (YL)
173 (BL)
134 (WH)
176 (YL)



Trans, Gen 4, 2000 Series, RE

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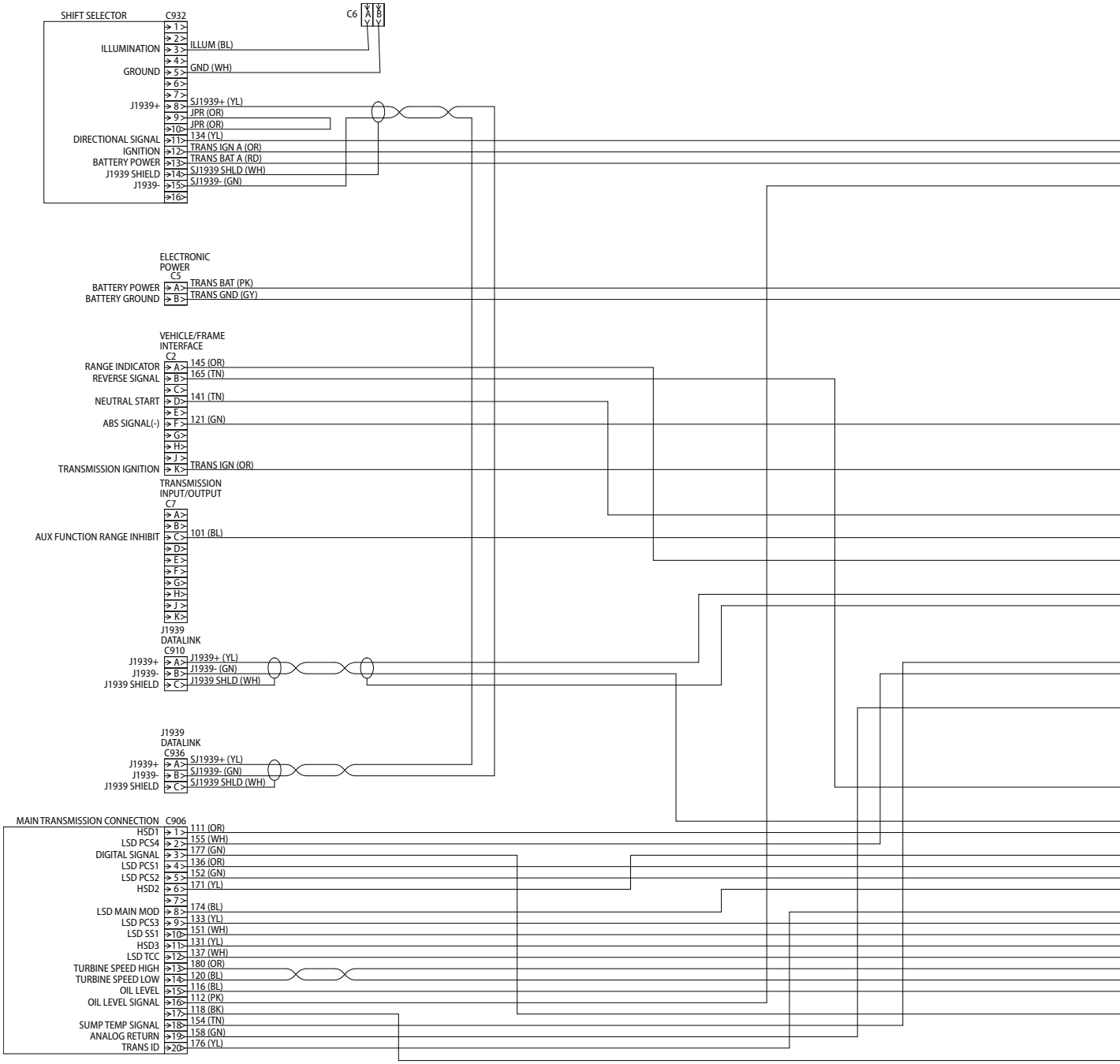
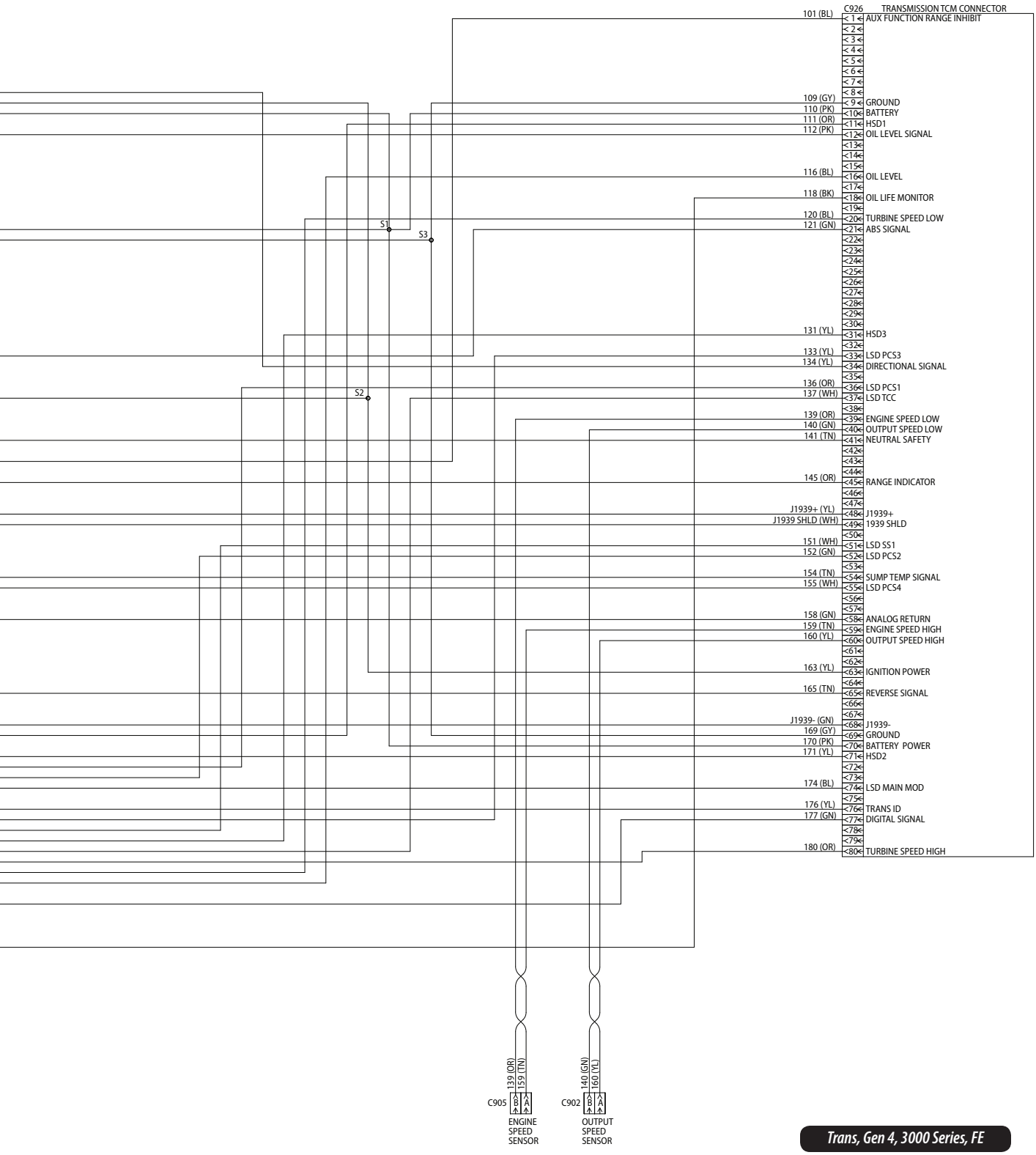

SHIFT SELECTOR
C932
C6
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939+
SJ1939+ (YL)
JPR (OR)
JPR (OR)
DIRECTIONAL SIGNAL
134 (YL)
IGNITION
TRANS IGN A (OR)
BATTERY POWER
TRANS BAT A (RD)
J1939 SHIELD
SJ1939 SHLD (WH)
J1939-
SJ1939- (GN)
ELECTRONIC POWER
C5
BATTERY POWER
TRANS BAT (PK)
BATTERY GROUND
TRANS GND (GY)
VEHICLE/FRAME INTERFACE
C2
RANGE INDICATOR
145 (OR)
REVERSE SIGNAL
165 (TN)
NEUTRAL START
141 (TN)
ABS SIGNAL(-)
121 (GN)
TRANSMISSION IGNITION
TRANS IGN (OR)
TRANSMISSION INPUT/OUTPUT
C7
AUX FUNCTION RANGE INHIBIT
101 (BL)
J1939 DATALINK
C910
J1939+
J1939+ (YL)
J1939-
J1939- (GN)
J1939 SHIELD
J1939 SHLD (WH)
J1939 DATALINK
C936
J1939+
SJ1939+ (YL)
J1939-
SJ1939- (GN)
J1939 SHIELD
SJ1939 SHLD (WH)
MAIN TRANSMISSION CONNECTION
C906
HSD1
111 (OR)
LSD PCS4
155 (WH)
DIGITAL SIGNAL
177 (GN)
LSD PCS1
136 (OR)
LSD PCS2
152 (GN)
HSD2
171 (YL)
LSD MAIN MOD
174 (BL)
LSD PCS3
133 (YL)
LSD SS1
151 (WH)
HSD3
131 (YL)
LSD TCC
137 (WH)
TURBINE SPEED HIGH
180 (OR)
TURBINE SPEED LOW
120 (BL)
OIL LEVEL
116 (BL)
OIL LEVEL SIGNAL
112 (PK)
118 (BK)
SUMP TEMP SIGNAL
154 (TN)
ANALOG RETURN
158 (GN)
TRANS ID
176 (YL)



Trans, Gen 4, 3000 Series, FE

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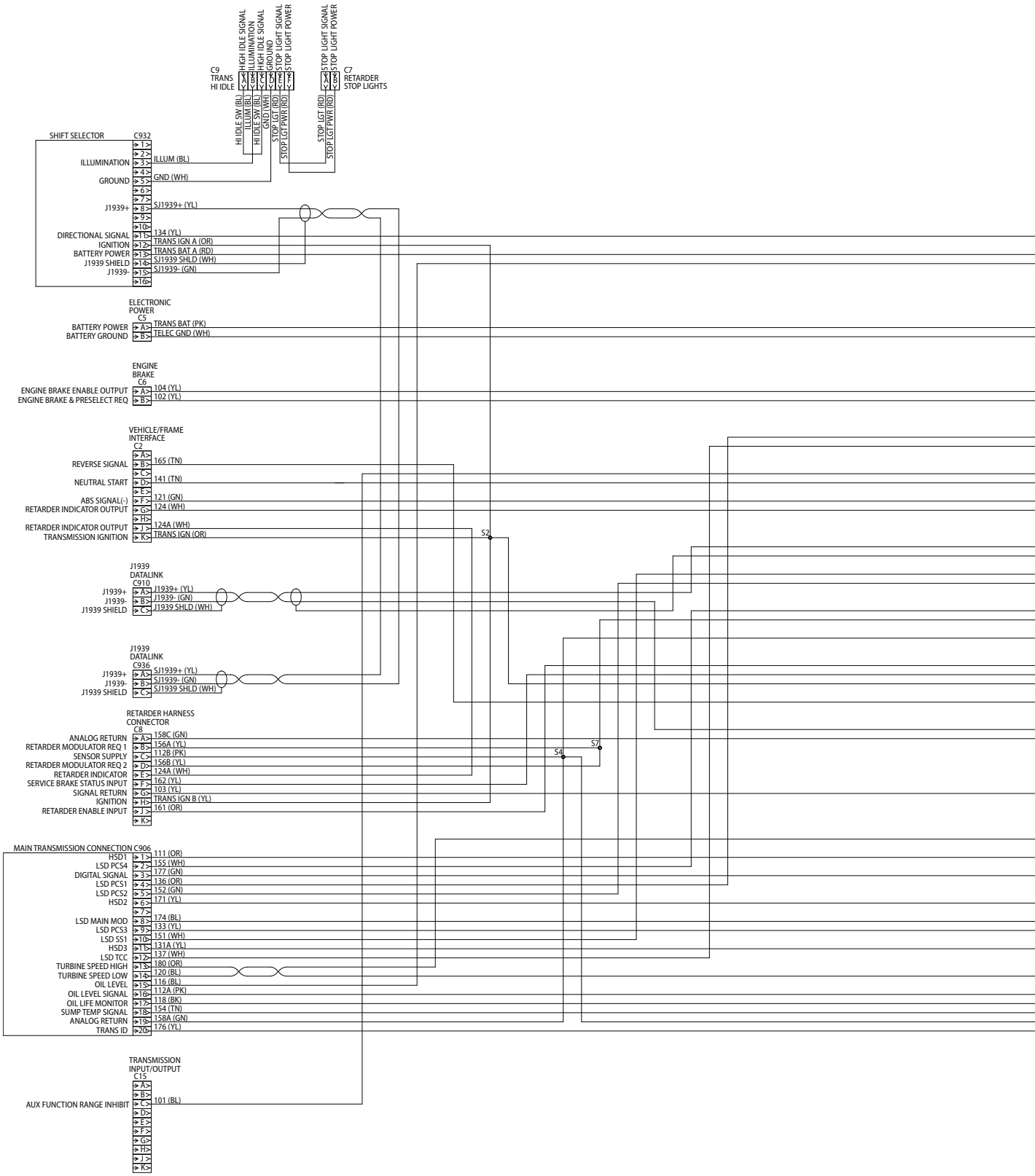
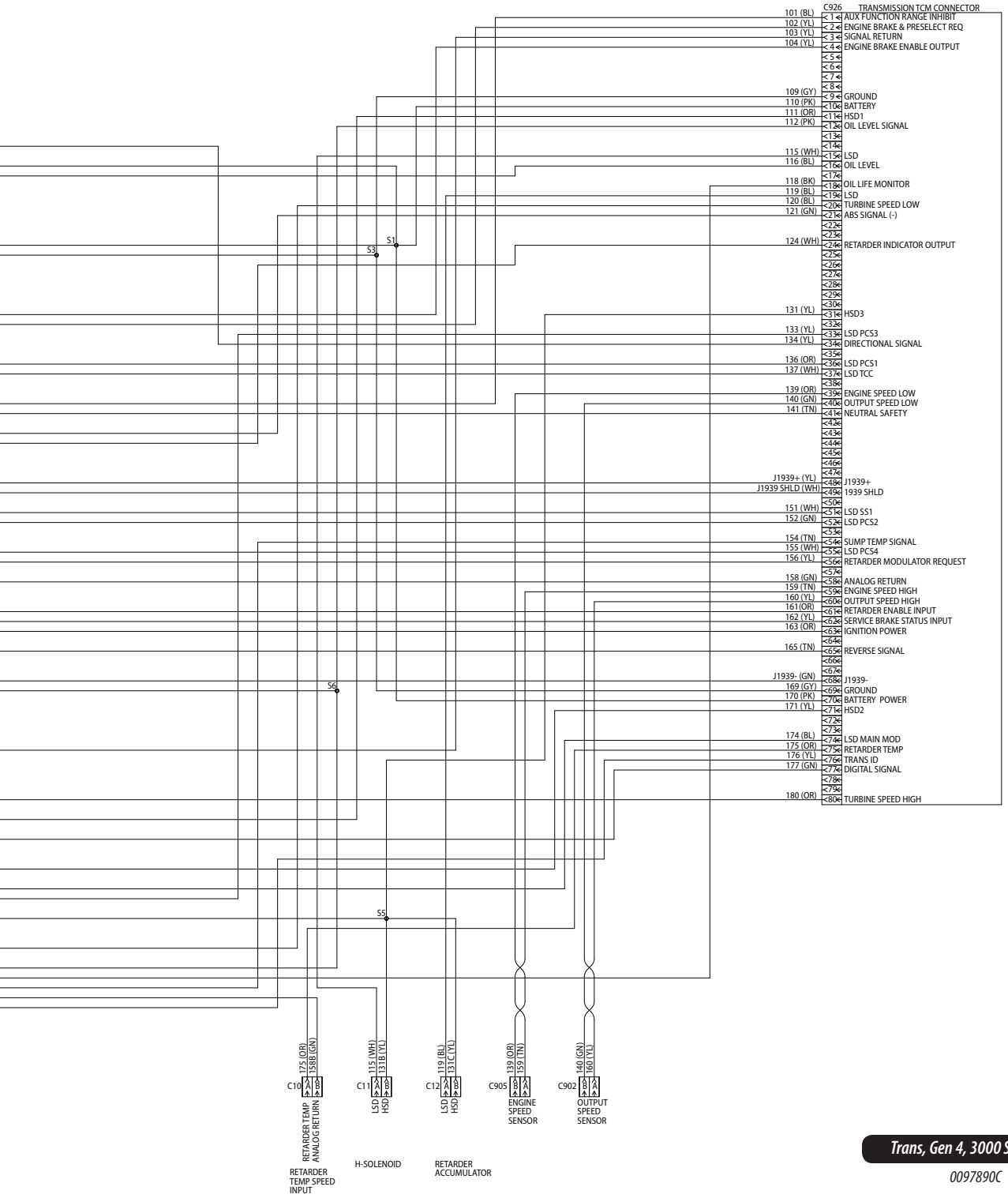
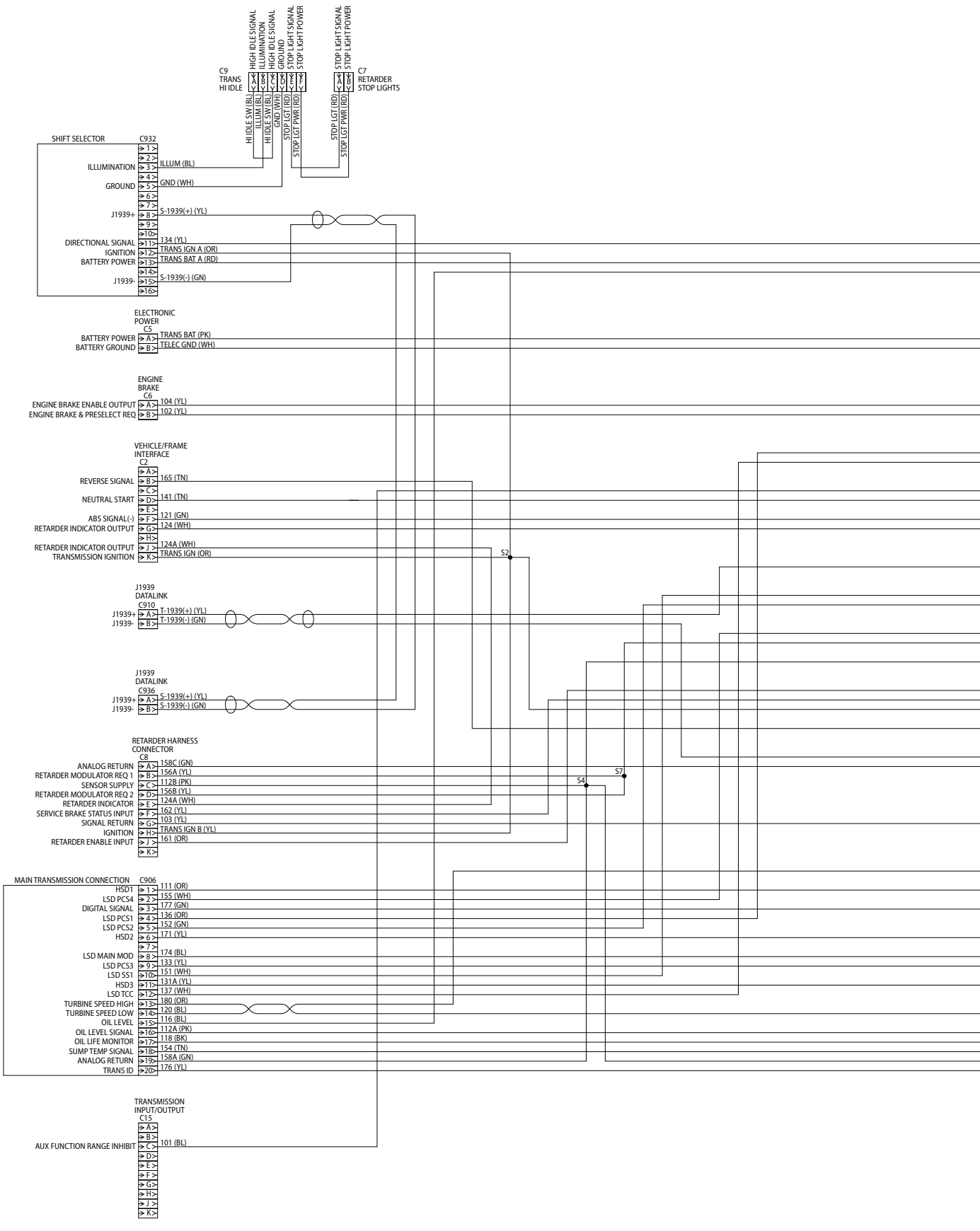
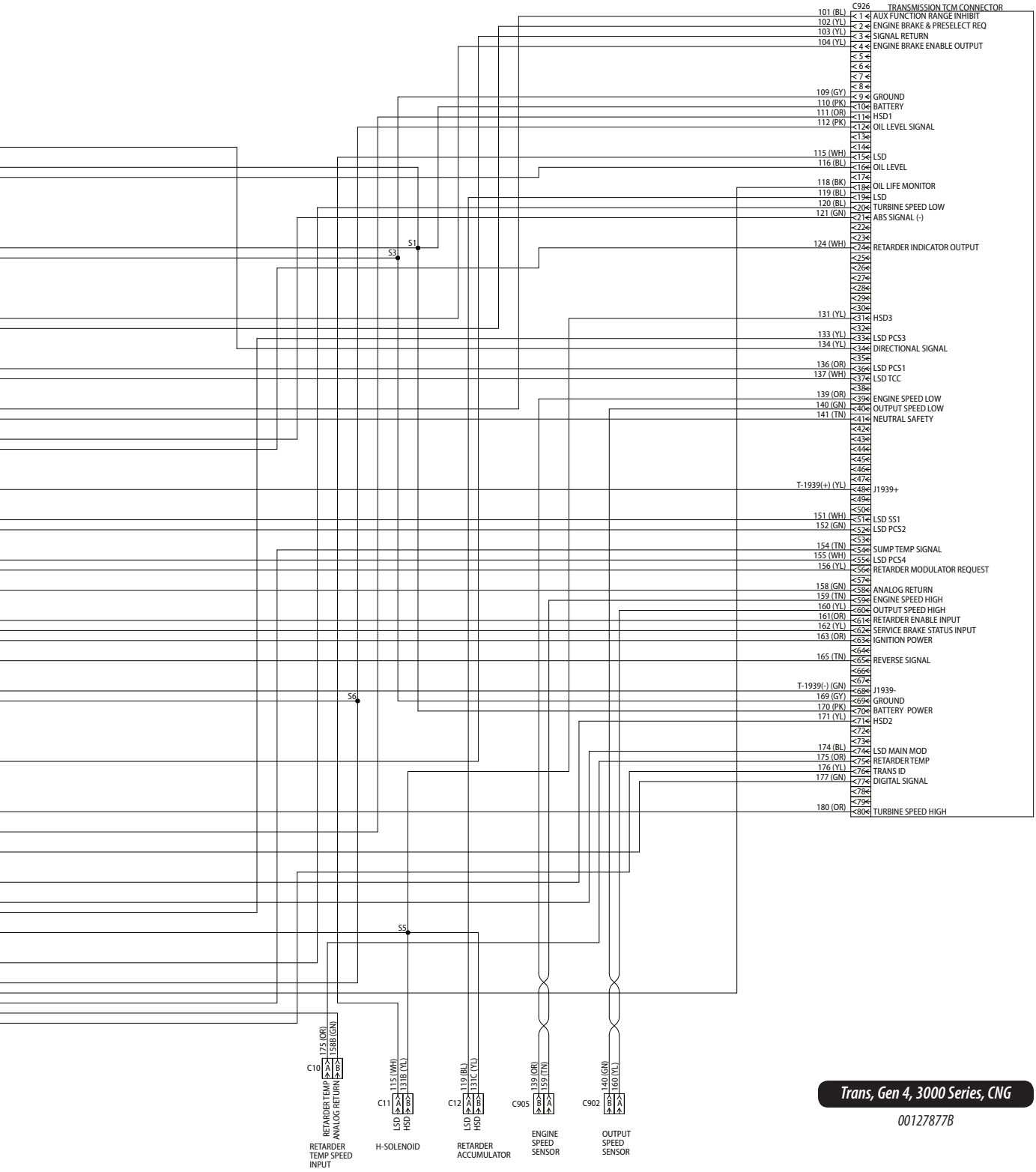

C9
TRANS
HI IDLE
HIGH IDLE SIGNAL
ILLUMINATION
HI IDLE SIGNAL
GROUND
STOP LIGHT SIGNAL
STOP LIGHT POWER
C7
RETARDER
STOP LIGHTS
STOP LIGHT SIGNAL
STOP LIGHT POWER
HI IDLE SW (BL)
ILLUM (BL)
HI IDLE SW (BL)
GND (WH)
STOP LGT (RD)
STOP LGT PWR (RD)
STOP LGT (RD)
STOP LGT PWR (RD)
SHIFT SELECTOR
C932
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939+
SJ1939+ (YL)
DIRECTIONAL SIGNAL
134 (YL)
IGNITION
TRANS IGN A (OR)
BATTERY POWER
TRANS BAT A (RD)
J1939 SHIELD
SJ1939 SHLD (WH)
J1939-
SJ1939- (GN)
ELECTRONIC
POWER
C5
BATTERY POWER
TRANS BAT (PK)
BATTERY GROUND
TELEC GND (WH)
ENGINE
BRAKE
C6
ENGINE BRAKE ENABLE OUTPUT
104 (YL)
ENGINE BRAKE & PRESELECT REQ
102 (YL)
VEHICLE/FRAME
INTERFACE
C2
REVERSE SIGNAL
165 (TN)
NEUTRAL START
141 (TN)
ABS SIGNAL(-)
121 (GN)
RETARDER INDICATOR OUTPUT
124 (WH)
RETARDER INDICATOR OUTPUT
124A (WH)
TRANSMISSION IGNITION
TRANS IGN (OR)
S2
J1939
DATALINK
C910
J1939+
J1939+ (YL)
J1939-
J1939- (GN)
J1939 SHIELD
J1939 SHLD (WH)
J1939
DATALINK
C936
J1939+
SJ1939+ (YL)
J1939-
SJ1939- (GN)
J1939 SHIELD
SJ1939 SHLD (WH)
RETARDER HARNESS
CONNECTOR
C8
ANALOG RETURN
158C (GN)
RETARDER MODULATOR REQ 1
156A (YL)
SENSOR SUPPLY
112B (PK)
RETARDER MODULATOR REQ 2
156B (YL)
RETARDER INDICATOR
124A (WH)
SERVICE BRAKE STATUS INPUT
162 (YL)
SIGNAL RETURN
103 (YL)
IGNITION
TRANS IGN B (YL)
RETARDER ENABLE INPUT
161 (OR)
S7
S4
MAIN TRANSMISSION CONNECTION C906
HSD1
111 (OR)
LSD PCS4
155 (WH)
DIGITAL SIGNAL
177 (GN)
LSD PCS1
136 (OR)
LSD PCS2
152 (GN)
HSD2
171 (YL)
LSD MAIN MOD
174 (BL)
LSD PCS3
133 (YL)
LSD SS1
151 (WH)
HSD3
131A (YL)
LSD TCC
137 (WH)
TURBINE SPEED HIGH
180 (OR)
TURBINE SPEED LOW
120 (BL)
OIL LEVEL
116 (BL)
OIL LEVEL SIGNAL
112A (PK)
OIL LIFE MONITOR
118 (BK)
SUMP TEMP SIGNAL
154 (TN)
ANALOG RETURN
158A (GN)
TRANS ID
176 (YL)
TRANSMISSION
INPUT/OUTPUT
C15
AUX FUNCTION RANGE INHIBIT
101 (BL)

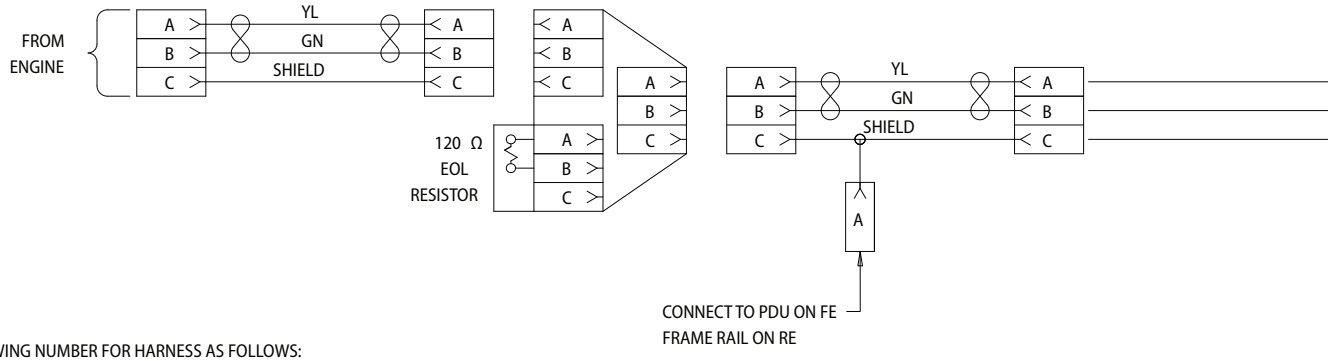

C926 TRANSMISSION TCM CONNECTOR
101 (BL) <1< AUX FUNCTION RANGE INHIBIT
102 (YL) <2< ENGINE BRAKE & PRESELECT REQ
103 (YL) <3< SIGNAL RETURN
104 (YL) <4< ENGINE BRAKE ENABLE OUTPUT
<5<
<6<
<7<
<8<
109 (GY) <9< GROUND
110 (PK) <10< BATTERY
111 (OR) <11< HSD1
112 (PK) <12< OIL LEVEL SIGNAL
<13<
<14<
115 (WH) <15< LSD
116 (BL) <16< OIL LEVEL
<17<
118 (BK) <18< OIL LIFE MONITOR
119 (BL) <19< LSD
120 (BL) <20< TURBINE SPEED LOW
121 (GN) <21< ABS SIGNAL (-)
<22<
<23<
124 (WH) <24< RETARDER INDICATOR OUTPUT
<25<
<26<
<27<
<28<
<29<
<30<
131 (YL) <31< HSD3
<32<
133 (YL) <33< LSD PCS3
134 (YL) <34< DIRECTIONAL SIGNAL
<35<
136 (OR) <36< LSD PCS1
137 (WH) <37< LSD TCC
<38<
139 (OR) <39< ENGINE SPEED LOW
140 (GN) <40< OUTPUT SPEED LOW
141 (TN) <41< NEUTRAL SAFETY
<42<
<43<
<44<
<45<
<46<
<47<
J1939+ (YL) <48< J1939+
J1939 SHLD (WHI) <49< 1939 SHLD
<50<
151 (WH) <51< LSD SS1
152 (GN) <52< LSD PCS2
<53<
154 (TN) <54< SUMP TEMP SIGNAL
155 (WH) <55< LSD PCS4
156 (YL) <56< RETARDER MODULATOR REQUEST
<57<
158 (GN) <58< ANALOG RETURN
159 (TN) <59< ENGINE SPEED HIGH
160 (YL) <60< OUTPUT SPEED HIGH
161 (OR) <61< RETARDER ENABLE INPUT
162 (YL) <62< SERVICE BRAKE STATUS INPUT
163 (OR) <63< IGNITION POWER
<64<
165 (TN) <65< REVERSE SIGNAL
<66<
<67<
J1939- (GN) <68< J1939-
169 (GY) <69< GROUND
170 (PK) <70< BATTERY POWER
171 (YL) <71< HSD2
<72<
<73<
174 (BL) <74< LSD MAIN MOD
175 (OR) <75< RETARDER TEMP
176 (YL) <76< TRANS ID
177 (GN) <77< DIGITAL SIGNAL
<78<
<79<
180 (OR) <80< TURBINE SPEED HIGH
S1
S3
S6
S5
C10 175 (OR) 158B (GN)
RETARDER TEMP
ANALOG RETURN
RETARDER TEMP SPEED INPUT
C11 115 (WH) 131B (YL)
LSD
HSD
H-SOLENOID
C12 119 (BL) 131C (YL)
LSD
HSD
RETARDER ACCUMULATOR
C905 139 (OR) 159 (TN)
ENGINE SPEED SENSOR
C902 140 (GN) 160 (YL)
OUTPUT SPEED SENSOR


C9
TRANS
HI IDLE
HIGH IDLE SIGNAL
ILLUMINATION
HIGH IDLE SIGNAL
GROUND
STOP LIGHT SIGNAL
STOP LIGHT POWER
HI IDLE SW (BL)
ILLUM (BL)
HI IDLE SW (BL)
GND (WH)
STOP LGT (RD)
STOP LGT PWR (RD)
C7
RETARDER
STOP LIGHTS
STOP LIGHT SIGNAL
STOP LIGHT POWER
STOP LGT (RD)
STOP LGT PWR (RD)
SHIFT SELECTOR
C932
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939+
S-1939(+) (YL)
J1939-
S-1939(-) (GN)
DIRECTIONAL SIGNAL
134 (YL)
IGNITION
TRANS IGN A (OR)
BATTERY POWER
TRANS BAT A (RD)
ELECTRONIC
POWER
C5
BATTERY POWER
TRANS BAT (PK)
BATTERY GROUND
TELEC GND (WH)
ENGINE
BRAKE
C6
ENGINE BRAKE ENABLE OUTPUT
104 (YL)
ENGINE BRAKE & PRESELECT REQ
102 (YL)
VEHICLE/FRAME
INTERFACE
C2
REVERSE SIGNAL
165 (TN)
NEUTRAL START
141 (TN)
ABS SIGNAL(-)
121 (GN)
RETARDER INDICATOR OUTPUT
124 (WH)
RETARDER INDICATOR OUTPUT
124A (WH)
TRANSMISSION IGNITION
TRANS IGN (OR)
S2
J1939
DATALINK
C910
J1939+
T-1939(+) (YL)
J1939-
T-1939(-) (GN)
J1939
DATALINK
C936
J1939+
S-1939(+) (YL)
J1939-
S-1939(-) (GN)
RETARDER HARNESS
CONNECTOR
C8
ANALOG RETURN
158C (GN)
RETARDER MODULATOR REQ 1
156A (YL)
SENSOR SUPPLY
112B (PK)
RETARDER MODULATOR REQ 2
156B (YL)
RETARDER INDICATOR
124A (WH)
SERVICE BRAKE STATUS INPUT
162 (YL)
SIGNAL RETURN
103 (YL)
IGNITION
TRANS IGN B (YL)
RETARDER ENABLE INPUT
161 (OR)
S4
S7
MAIN TRANSMISSION CONNECTION
C906
HSD1
111 (OR)
LSD PCS4
155 (WH)
DIGITAL SIGNAL
177 (GN)
LSD PCS1
136 (OR)
LSD PCS2
152 (GN)
HSD2
171 (YL)
LSD MAIN MOD
174 (BL)
LSD PCS3
133 (YL)
LSD SS1
151 (WH)
HSD3
131A (YL)
LSD TCC
137 (WH)
TURBINE SPEED HIGH
180 (OR)
TURBINE SPEED LOW
120 (BL)
OIL LEVEL
116 (BL)
OIL LEVEL SIGNAL
112A (PK)
OIL LIFE MONITOR
118 (BK)
SUMP TEMP SIGNAL
154 (TN)
ANALOG RETURN
158A (GN)
TRANS ID
176 (YL)
TRANSMISSION
INPUT/OUTPUT
C15
AUX FUNCTION RANGE INHIBIT
101 (BL)



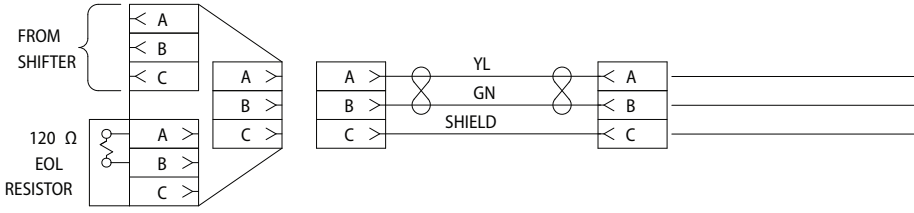
Trans, Gen 4, 3000 Series, CNG

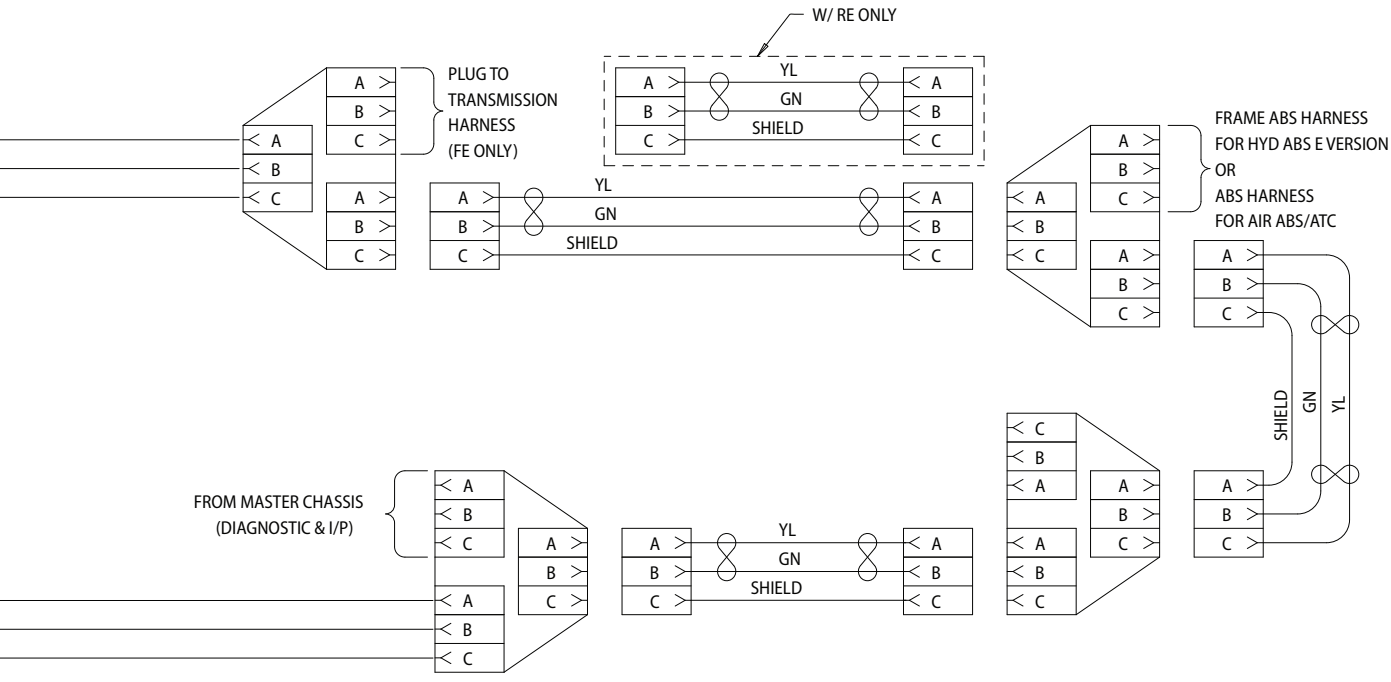
00127877B



NOTE:

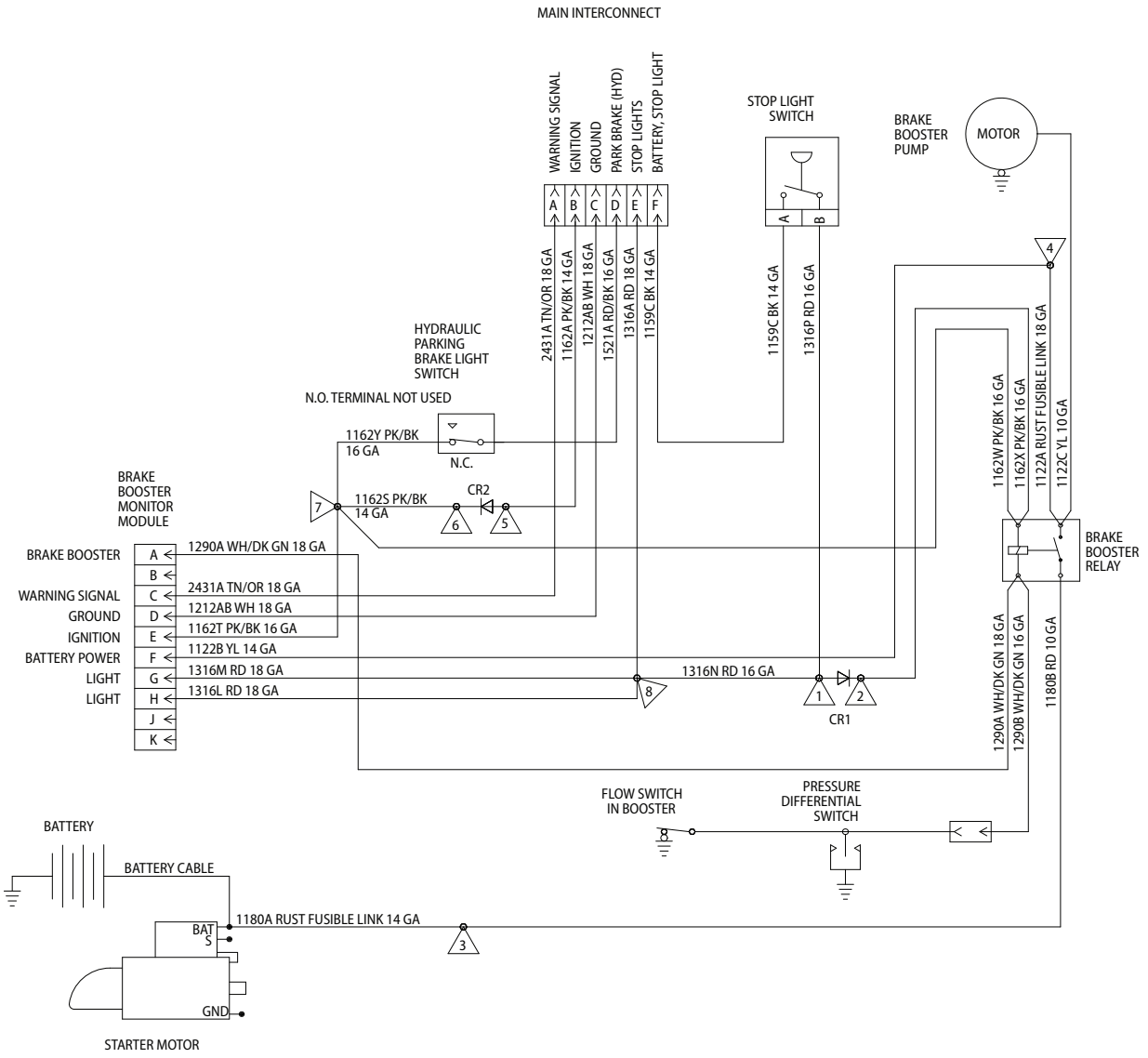
1. SEE DRAWING NUMBER FOR HARNESS AS FOLLOWS:
   0117916 DIAGRAM,WRG,DATALINK,J1939,HYD,E-VER HDFE
   0117924 DIAGRAM,HARNESS,WRG,DATALINK,J1939,BDX,HDFE





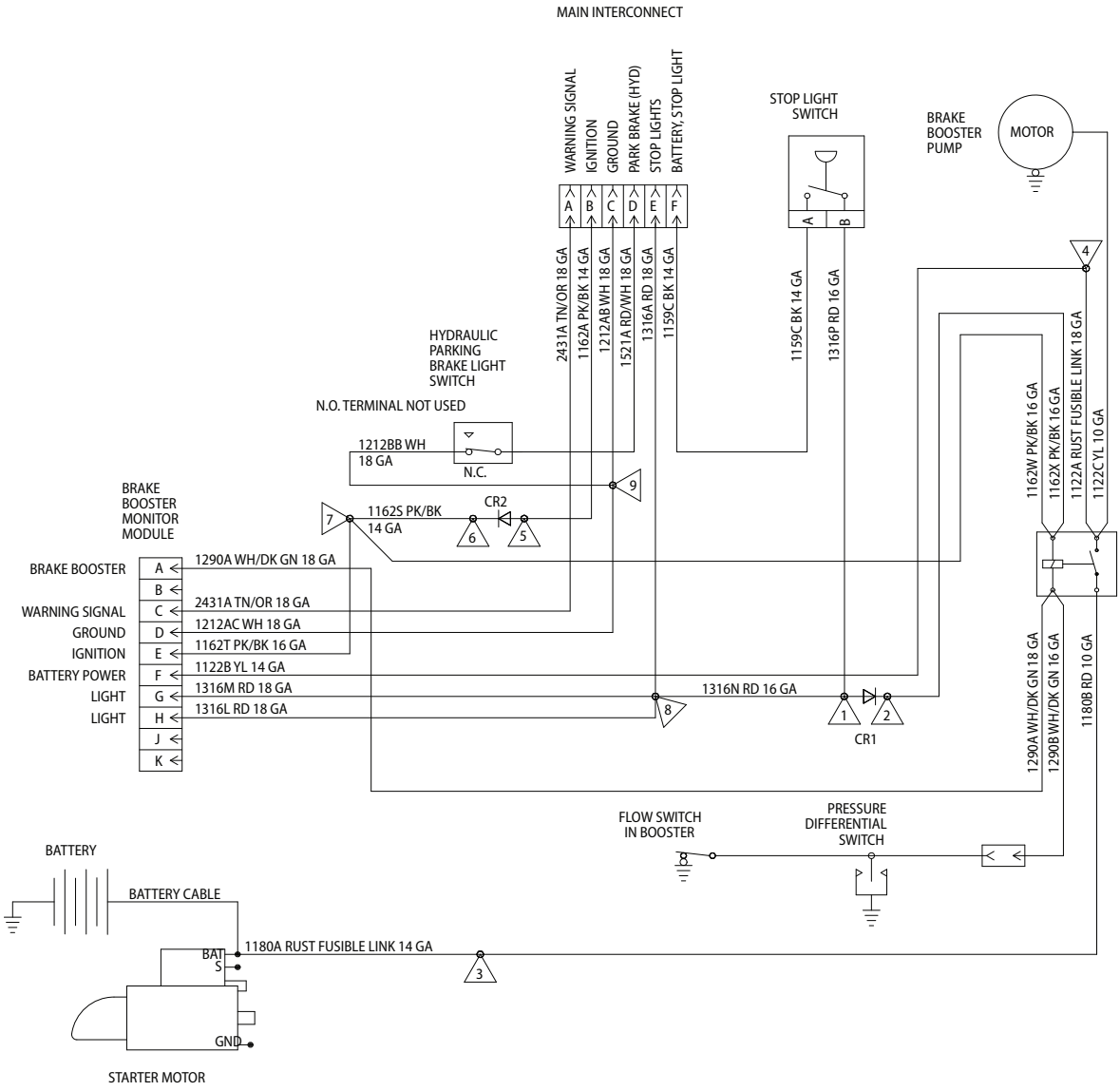
Datalink, J1939, FE & RE

0111653B



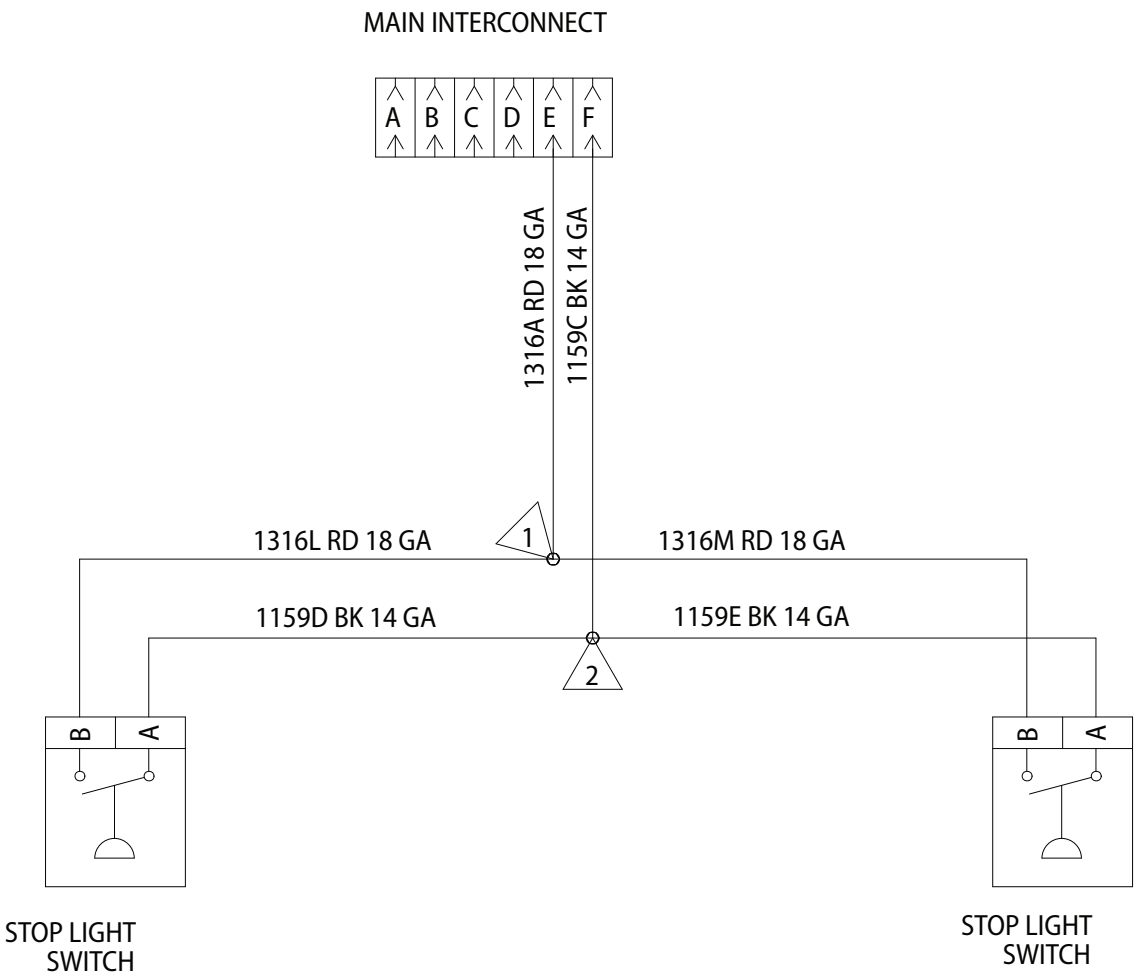
Brakes, Hyd, Standard FE

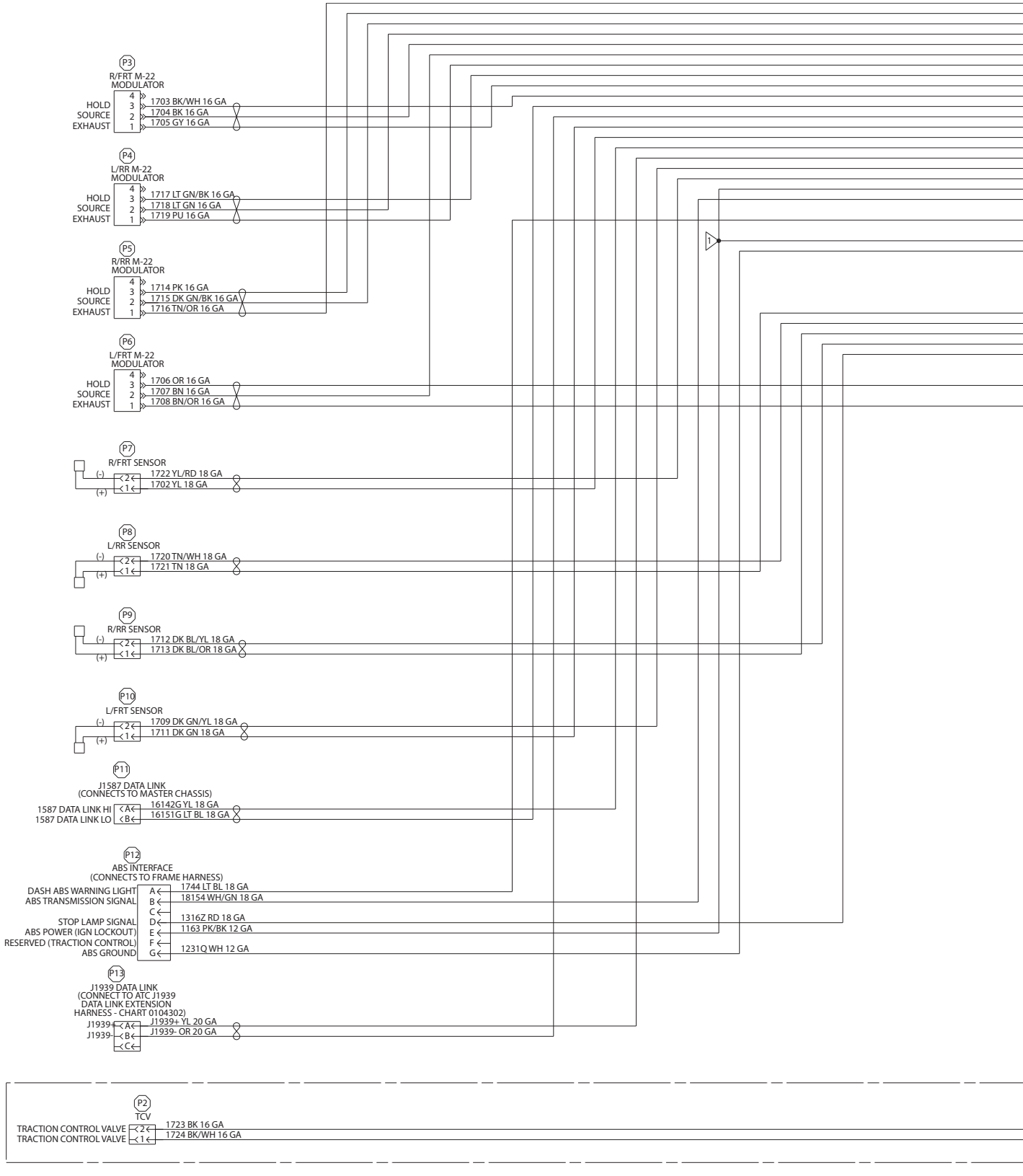
0014747B

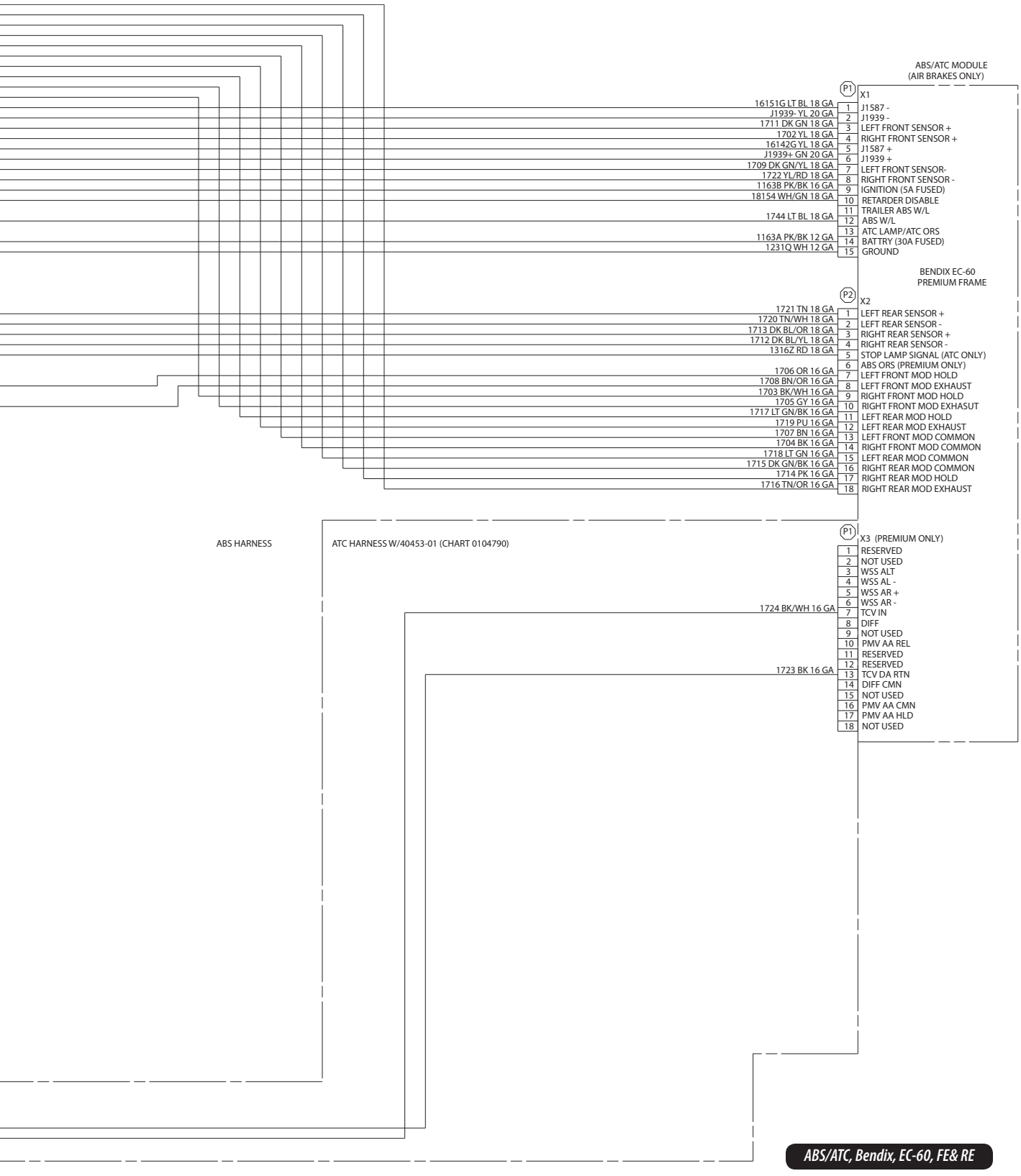


Brakes, Hyd, w/Lift Control, FE

0014747B

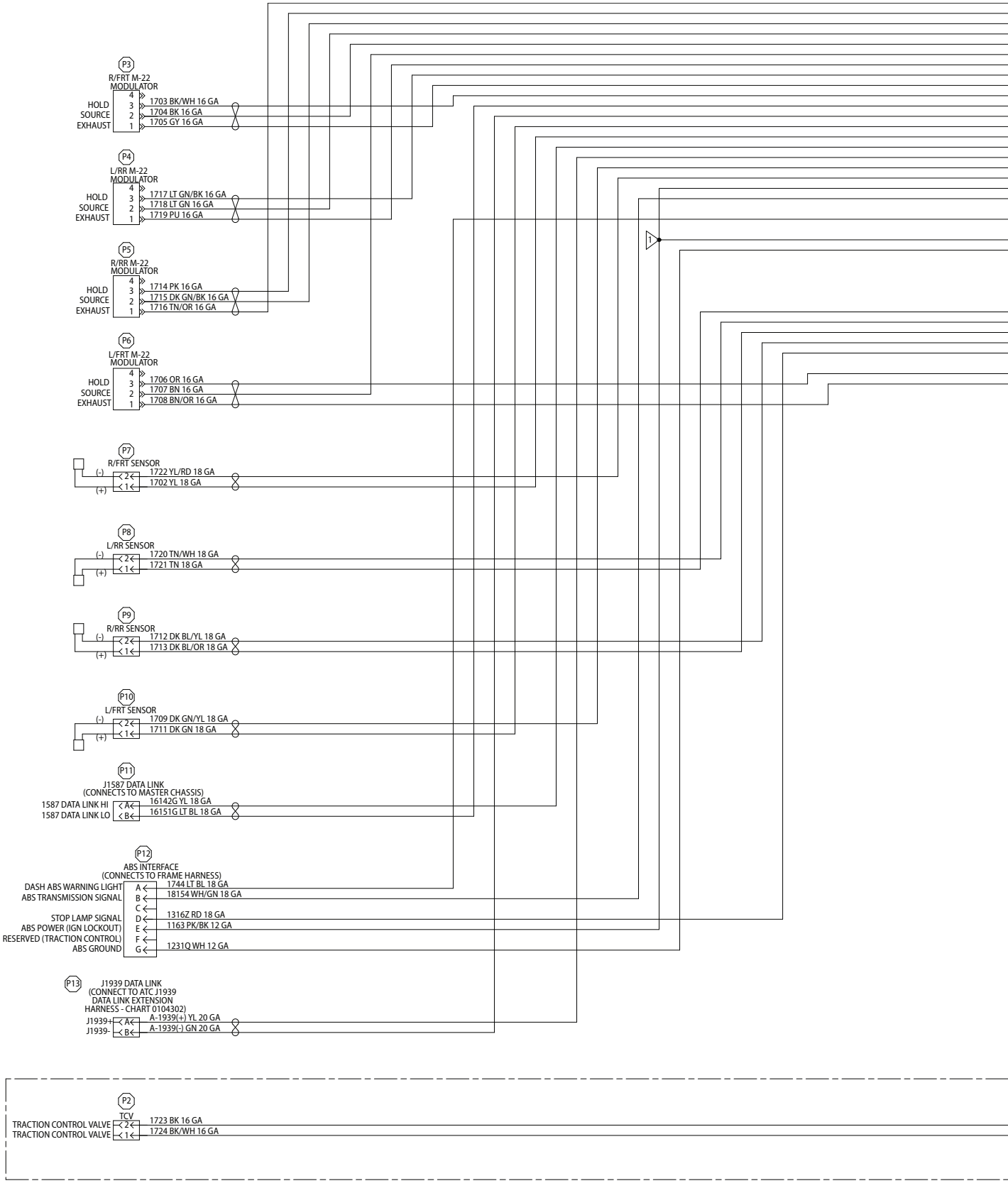

MAIN INTERCONNECT
A
B
C
D
E
F
1316A RD 18 GA
1159C BK 14 GA
1316L RD 18 GA
1
1316M RD 18 GA
1159D BK 14 GA
1159E BK 14 GA
2
B
A
B
A
STOP LIGHT SWITCH
STOP LIGHT SWITCH

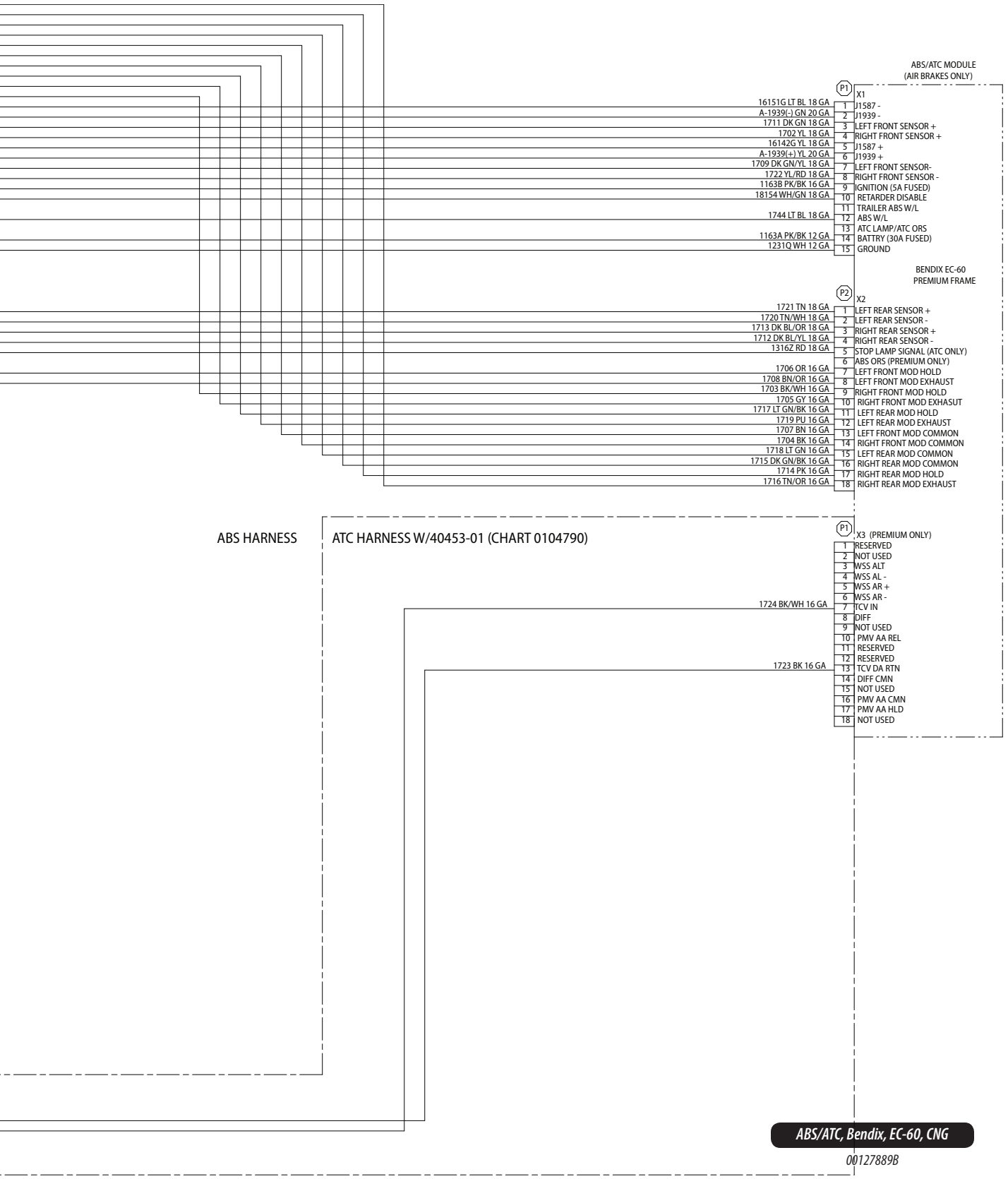

P3
R/FRT M-22 MODULATOR
HOLD
SOURCE
EXHAUST
4
3
2
1
1703 BK/WH 16 GA
1704 BK 16 GA
1705 GY 16 GA
P4
L/RR M-22 MODULATOR
1717 LT GN/BK 16 GA
1718 LT GN 16 GA
1719 PU 16 GA
P5
R/RR M-22 MODULATOR
1714 PK 16 GA
1715 DK GN/BK 16 GA
1716 TN/OR 16 GA
P6
L/FRT M-22 MODULATOR
1706 OR 16 GA
1707 BN 16 GA
1708 BN/OR 16 GA
P7
R/FRT SENSOR
(-)
(+)
2
1
1722 YL/RD 18 GA
1702 YL 18 GA
P8
L/RR SENSOR
1720 TN/WH 18 GA
1721 TN 18 GA
P9
R/RR SENSOR
1712 DK BL/YL 18 GA
1713 DK BL/OR 18 GA
P10
L/FRT SENSOR
1709 DK GN/YL 18 GA
1711 DK GN 18 GA
P11
J1587 DATA LINK
(CONNECTS TO MASTER CHASSIS)
1587 DATA LINK HI
1587 DATA LINK LO
A
B
16142G YL 18 GA
16151G LT BL 18 GA
P12
ABS INTERFACE
(CONNECTS TO FRAME HARNESS)
DASH ABS WARNING LIGHT
ABS TRANSMISSION SIGNAL
STOP LAMP SIGNAL
ABS POWER (IGN LOCKOUT)
RESERVED (TRACTION CONTROL)
ABS GROUND
A
B
C
D
E
F
G
1744 LT BL 18 GA
18154 WH/GN 18 GA
1316Z RD 18 GA
1163 PK/BK 12 GA
1231Q WH 12 GA
P13
J1939 DATA LINK
(CONNECT TO ATC J1939 DATA LINK EXTENSION HARNESS - CHART 0104302)
J1939+
J1939-
A
B
C
J1939+ YL 20 GA
J1939- OR 20 GA
1
P2
TCV
TRACTION CONTROL VALVE
TRACTION CONTROL VALVE
2
1
1723 BK 16 GA
1724 BK/WH 16 GA



ABS/ATC, Bendix, EC-60, FE& RE

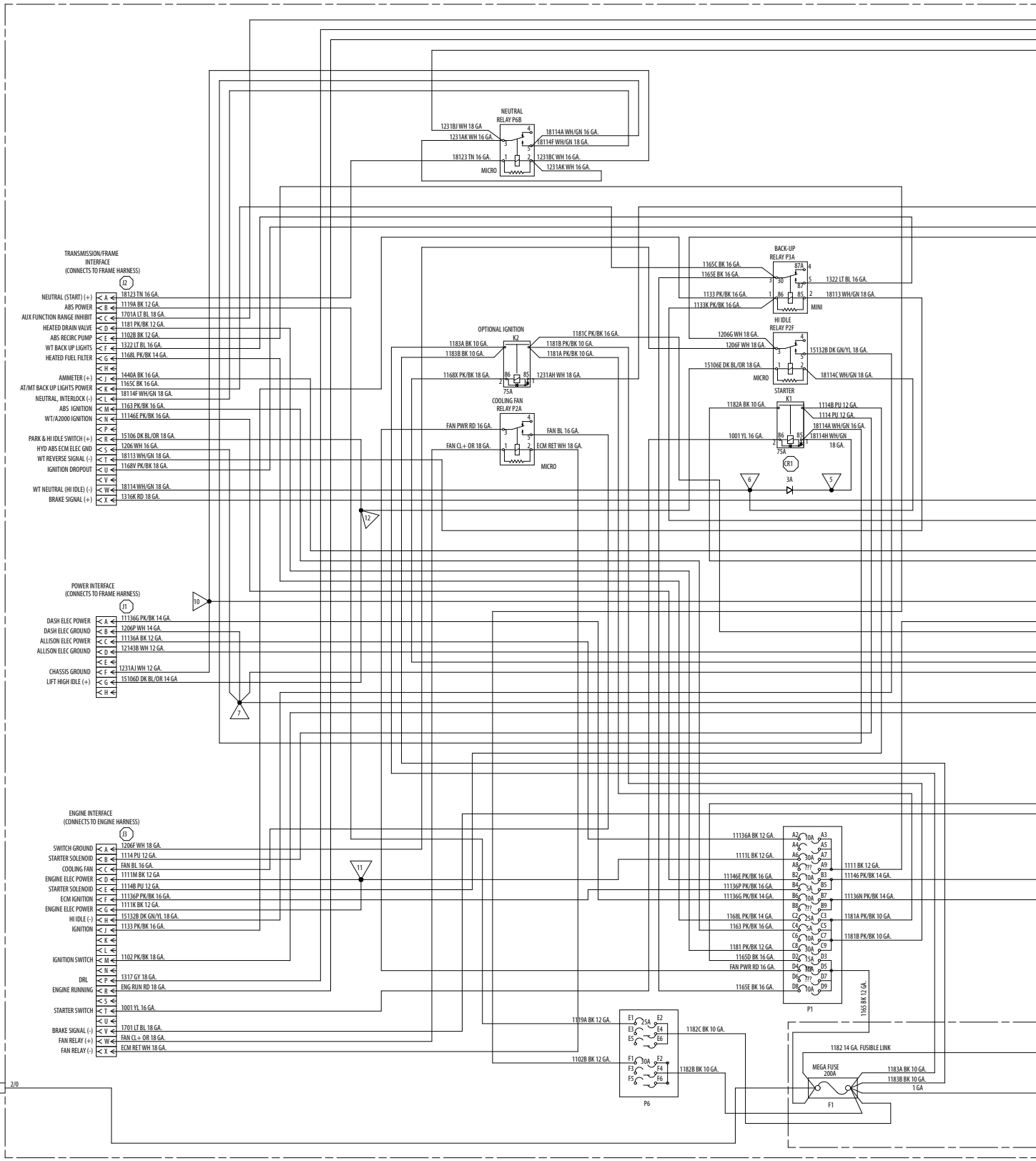
0104290

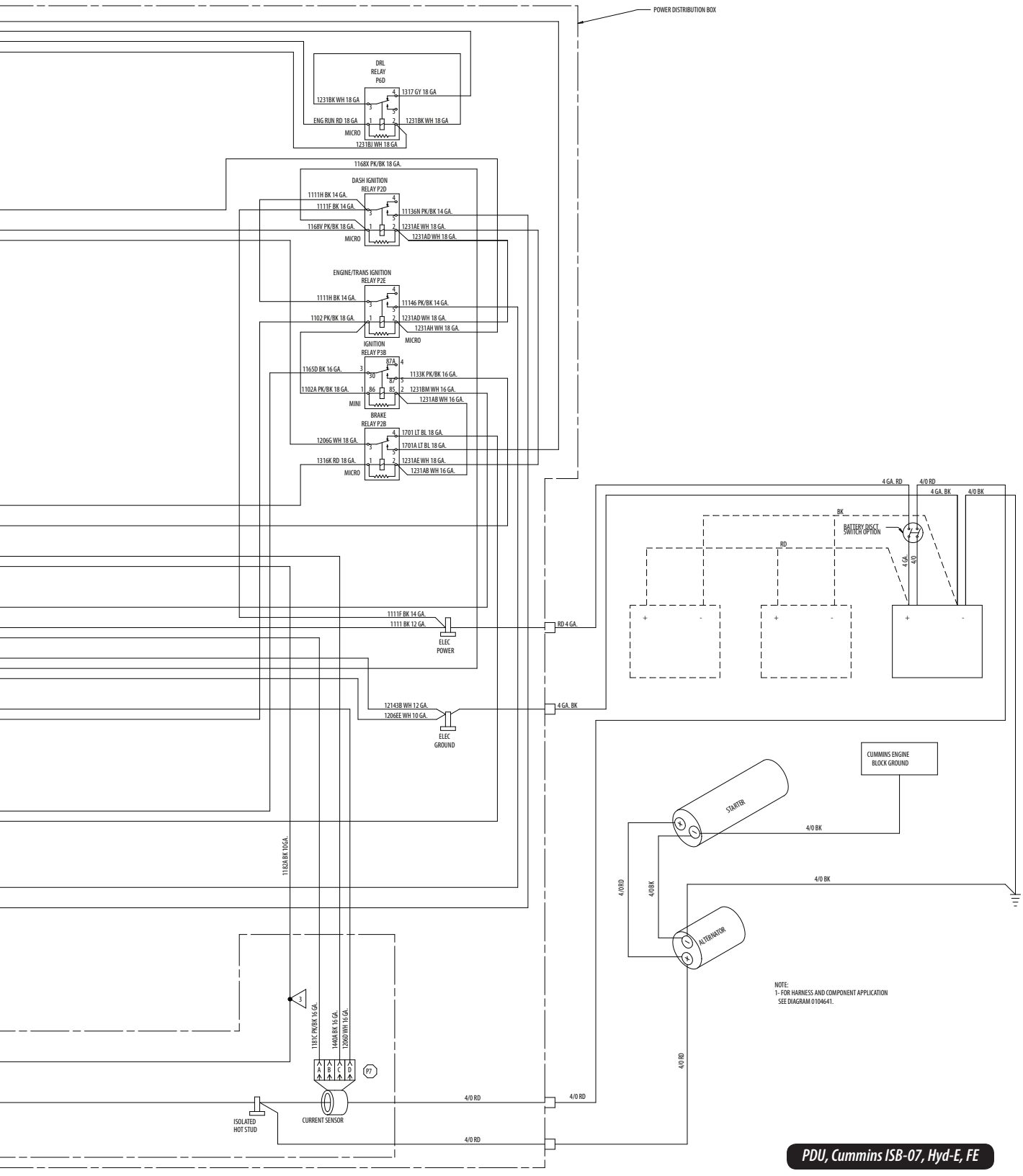

P3
R/FRT M-22 MODULATOR
HOLD
SOURCE
EXHAUST
1703 BK/WH 16 GA
1704 BK 16 GA
1705 GY 16 GA
P4
L/RR M-22 MODULATOR
1717 LT GN/BK 16 GA
1718 LT GN 16 GA
1719 PU 16 GA
P5
R/RR M-22 MODULATOR
1714 PK 16 GA
1715 DK GN/BK 16 GA
1716 TN/OR 16 GA
P6
L/FRT M-22 MODULATOR
1706 OR 16 GA
1707 BN 16 GA
1708 BN/OR 16 GA
P7
R/FRT SENSOR
(-)
(+)
1722 YL/RD 18 GA
1702 YL 18 GA
P8
L/RR SENSOR
1720 TN/WH 18 GA
1721 TN 18 GA
P9
R/RR SENSOR
1712 DK BL/YL 18 GA
1713 DK BL/OR 18 GA
P10
L/FRT SENSOR
1709 DK GN/YL 18 GA
1711 DK GN 18 GA
P11
J1587 DATA LINK
(CONNECTS TO MASTER CHASSIS)
1587 DATA LINK HI
1587 DATA LINK LO
16142G YL 18 GA
16151G LT BL 18 GA
P12
ABS INTERFACE
(CONNECTS TO FRAME HARNESS)
DASH ABS WARNING LIGHT
ABS TRANSMISSION SIGNAL
STOP LAMP SIGNAL
ABS POWER (IGN LOCKOUT)
RESERVED (TRACTION CONTROL)
ABS GROUND
1744 LT BL 18 GA
18154 WH/GN 18 GA
1316Z RD 18 GA
1163 PK/BK 12 GA
1231Q WH 12 GA
P13
J1939 DATA LINK
(CONNECT TO ATC J1939 DATA LINK EXTENSION HARNESS - CHART 0104302)
J1939+
J1939-
A-1939(+) YL 20 GA
A-1939(-) GN 20 GA
1
P2
TCV
TRACTION CONTROL VALVE
TRACTION CONTROL VALVE
1723 BK 16 GA
1724 BK/WH 16 GA



ABS/ATC, Bendix, EC-60, CNG

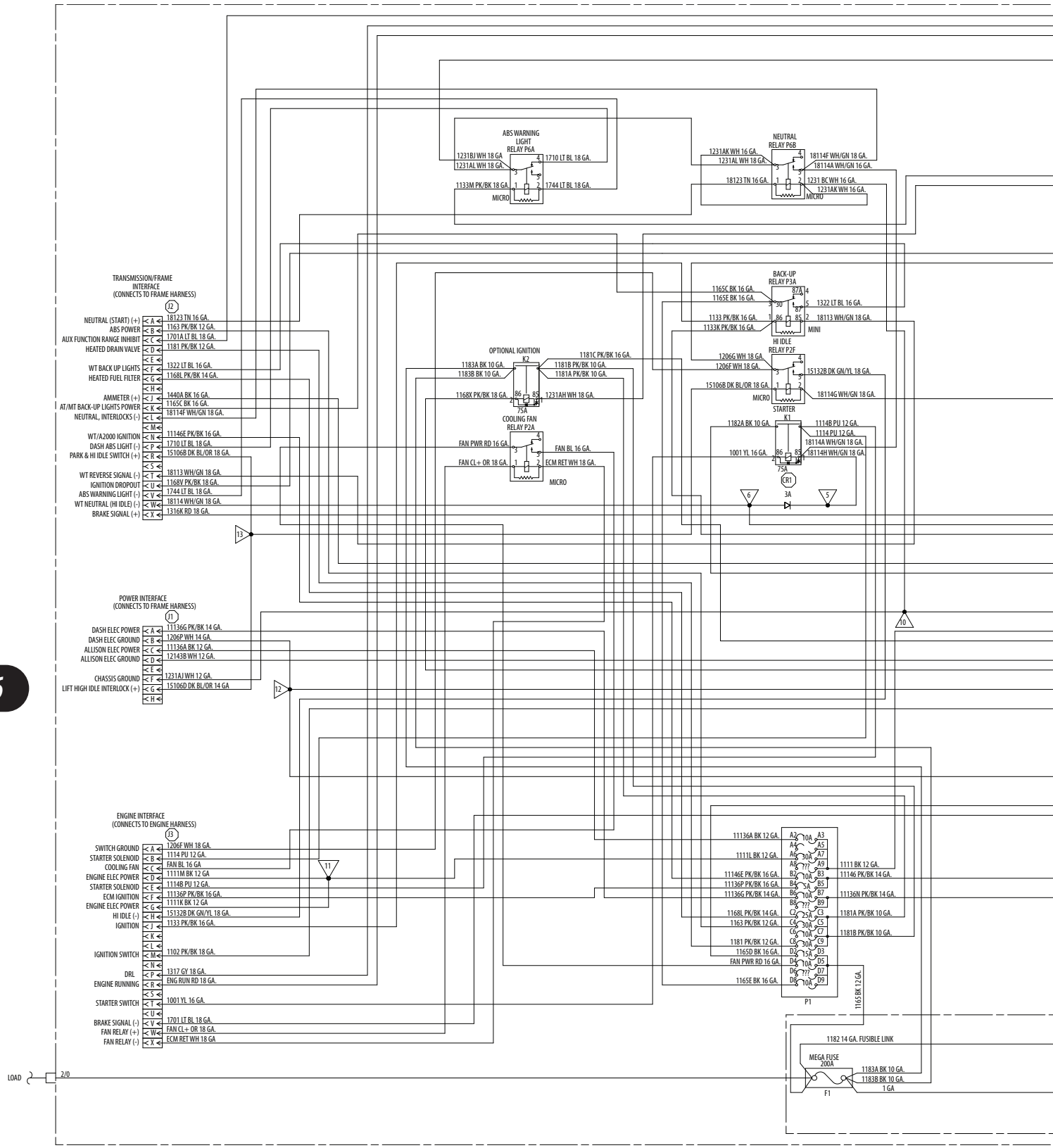
00127889B

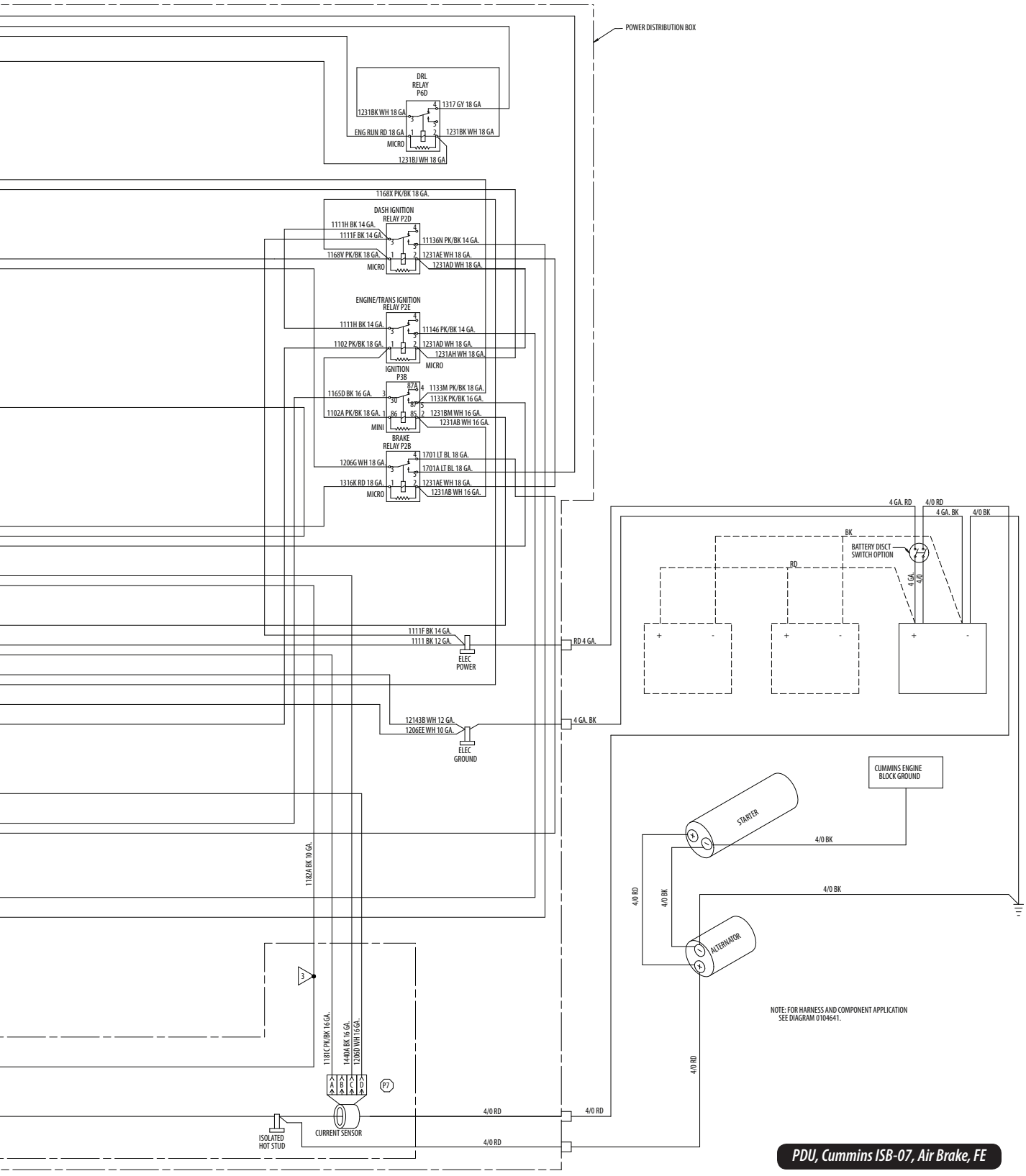

NEUTRAL RELAY P6B
12318J WH 18 GA
1231AK WH 16 GA.
18114A WH/GN 16 GA.
18114F WH/GN 18 GA.
18123 TN 16 GA.
1231BC WH 16 GA.
1231AK WH 16 GA.
MICRO
TRANSMISSION/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
NEUTRAL (START) (+)
ABS POWER
AUX FUNCTION RANGE INHIBIT
HEATED DRAIN VALVE
ABS RECIRC PUMP
WT BACK UP LIGHTS
HEATED FUEL FILTER
AMMETER (+)
AT/MT BACK UP LIGHTS POWER
NEUTRAL, INTERLOCK (-)
ABS IGNITION
WT/A2000 IGNITION
PARK & HI IDLE SWITCH (+)
HYD ABS ECM ELEC GND
WT REVERSE SIGNAL (-)
IGNITION DROPOUT
WT NEUTRAL (HI IDLE) (-)
BRAKE SIGNAL (+)
18123 TN 16 GA.
1119A BK 12 GA.
1701A LT BL 18 GA.
1181 PK/BK 12 GA.
1102B BK 12 GA.
1322 LT BL 16 GA.
1168L PK/BK 14 GA.
1440A BK 16 GA.
1165C BK 16 GA.
18114F WH/GN 18 GA.
1163 PK/BK 16 GA.
11146E PK/BK 16 GA.
15106 DK BL/OR 18 GA.
1206 WH 16 GA.
18113 WH/GN 18 GA.
1168V PK/BK 18 GA.
18114 WH/GN 18 GA.
1316K RD 18 GA.
OPTIONAL IGNITION
K2
1183A BK 10 GA.
1183B BK 10 GA.
1168X PK/BK 18 GA.
1231AH WH 18 GA.
1181C PK/BK 16 GA.
1181B PK/BK 10 GA.
1181A PK/BK 10 GA.
75A
COOLING FAN RELAY P2A
FAN PWR RD 16 GA.
FAN CL+ OR 18 GA.
FAN BL 16 GA.
ECM RET WH 18 GA.
MICRO
BACK-UP RELAY P3A
1165C BK 16 GA.
1165E BK 16 GA.
1133 PK/BK 16 GA.
1133K PK/BK 16 GA.
1322 LT BL 16 GA.
18113 WH/GN 18 GA.
MINI
HI IDLE RELAY P2F
1206G WH 18 GA.
1206F WH 18 GA.
15106E DK BL/OR 18 GA.
15132B DK GN/YL 18 GA.
18114C WH/GN 18 GA.
MICRO
STARTER
K1
1182A BK 10 GA.
1001 YL 16 GA.
1114B PU 12 GA.
1114 PU 12 GA.
18114A WH/GN 16 GA.
18114H WH/GN 18 GA.
75A
CR1
3A
12
POWER INTERFACE (CONNECTS TO FRAME HARNESS)
J1
10
DASH ELEC POWER
DASH ELEC GROUND
ALLISON ELEC POWER
ALLISON ELEC GROUND
CHASSIS GROUND
LIFT HIGH IDLE (+)
11136G PK/BK 14 GA.
1206P WH 14 GA.
11136A BK 12 GA.
12143B WH 12 GA.
1231AJ WH 12 GA.
15106D DK BL/OR 14 GA
7
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
J3
11
SWITCH GROUND
STARTER SOLENOID
COOLING FAN
ENGINE ELEC POWER
STARTER SOLENOID
ECM IGNITION
ENGINE ELEC POWER
HI IDLE (-)
IGNITION
IGNITION SWITCH
DRL
ENGINE RUNNING
STARTER SWITCH
BRAKE SIGNAL (-)
FAN RELAY (+)
FAN RELAY (-)
1206F WH 18 GA.
1114 PU 12 GA.
FAN BL 16 GA.
1111M BK 12 GA
1114B PU 12 GA.
11136P PK/BK 16 GA.
1111K BK 12 GA.
15132B DK GN/YL 18 GA.
1133 PK/BK 16 GA.
1102 PK/BK 18 GA.
1317 GY 18 GA.
ENG RUN RD 18 GA.
1001 YL 16 GA.
1701 LT BL 18 GA.
FAN CL+ OR 18 GA.
ECM RET WH 18 GA.
11136A BK 12 GA.
1111L BK 12 GA.
11146E PK/BK 16 GA.
11136P PK/BK 16 GA.
11136G PK/BK 14 GA.
1168L PK/BK 14 GA.
1163 PK/BK 16 GA.
1181 PK/BK 12 GA.
1165D BK 16 GA.
FAN PWR RD 16 GA.
1165E BK 16 GA.
1111 BK 12 GA.
11146 PK/BK 14 GA.
11136N PK/BK 14 GA.
1181A PK/BK 10 GA.
1181B PK/BK 10 GA.
P1
1165 BK 12 GA.
1119A BK 12 GA.
1102B BK 12 GA.
1182C BK 10 GA.
1182B BK 10 GA.
P6
1182 14 GA. FUSIBLE LINK
MEGA FUSE 200A
1183A BK 10 GA.
1183B BK 10 GA.
1 GA
F1
LOAD
2/0



PDU, Cummins ISB-07, Hyd-E, FE

0111640


ABS WARNING LIGHT RELAY P6A
1231BJ WH 18 GA
1231AL WH 18 GA
1710 LT BL 18 GA.
1133M PK/BK 18 GA.
1744 LT BL 18 GA.
MICRO
NEUTRAL RELAY P6B
1231AK WH 16 GA.
1231AL WH 18 GA.
18114F WH/GN 18 GA.
18114A WH/GN 16 GA.
18123 TN 16 GA.
1231 BC WH 16 GA.
1231AK WH 16 GA.
MICRO
TRANSMISSION/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
NEUTRAL (START) (+) A 18123 TN 16 GA.
ABS POWER B 1163 PK/BK 12 GA.
AUX FUNCTION RANGE INHIBIT C 1701A LT BL 18 GA.
HEATED DRAIN VALVE D 1181 PK/BK 12 GA.
E
WT BACK UP LIGHTS F 1322 LT BL 16 GA.
HEATED FUEL FILTER G 1168L PK/BK 14 GA.
H
AMMETER (+) J 1440A BK 16 GA.
AT/MT BACK-UP LIGHTS POWER K 1165C BK 16 GA.
NEUTRAL, INTERLOCKS (-) L 18114F WH/GN 18 GA.
M
WT/A2000 IGNITION N 11146E PK/BK 16 GA.
DASH ABS LIGHT (-) P 1710 LT BL 18 GA.
PARK & HI IDLE SWITCH (+) R 15106B DK BL/OR 18 GA.
S
WT REVERSE SIGNAL (-) T 18113 WH/GN 18 GA.
IGNITION DROPOUT U 1168V PK/BK 18 GA.
ABS WARNING LIGHT (-) V 1744 LT BL 18 GA.
WT NEUTRAL (HI IDLE) (-) W 18114 WH/GN 18 GA.
BRAKE SIGNAL (+) X 1316K RD 18 GA.
13
OPTIONAL IGNITION
K2
1183A BK 10 GA.
1183B BK 10 GA.
1181C PK/BK 16 GA.
1181B PK/BK 10 GA.
1181A PK/BK 10 GA.
1168X PK/BK 18 GA.
1231AH WH 18 GA.
75A
COOLING FAN RELAY P2A
FAN PWR RD 16 GA.
FAN BL 16 GA.
FAN CL+ OR 18 GA.
ECM RET WH 18 GA.
MICRO
BACK-UP RELAY P3A
1165C BK 16 GA.
1165E BK 16 GA.
1322 LT BL 16 GA.
1133 PK/BK 16 GA.
1133K PK/BK 16 GA.
18113 WH/GN 18 GA.
MINI
HI IDLE RELAY P2F
1206G WH 18 GA.
1206F WH 18 GA.
15132B DK GN/YL 18 GA.
15106B DK BL/OR 18 GA.
MICRO
18114G WH/GN 18 GA.
STARTER
K1
1182A BK 10 GA.
1114B PU 12 GA.
1114 PU 12 GA.
18114A WH/GN 18 GA.
1001 YL 16 GA.
18114H WH/GN 18 GA.
75A
CR1
3A
6
5
10
POWER INTERFACE (CONNECTS TO FRAME HARNESS)
J1
DASH ELEC POWER A 11136G PK/BK 14 GA.
DASH ELEC GROUND B 1206P WH 14 GA.
ALLISON ELEC POWER C 11136A BK 12 GA.
ALLISON ELEC GROUND D 12143B WH 12 GA.
E
CHASSIS GROUND F 1231AJ WH 12 GA.
LIFT HIGH IDLE INTERLOCK (+) G 15106D DK BL/OR 14 GA
H
12
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
J3
SWITCH GROUND A 1206F WH 18 GA.
STARTER SOLENOID B 1114 PU 12 GA.
COOLING FAN C 1111M BK 12 GA
ENGINE ELEC POWER D 1114B PU 12 GA.
STARTER SOLENOID E 11136P PK/BK 16 GA.
ECM IGNITION F 1111K BK 12 GA
ENGINE ELEC POWER G 15132B DK GN/YL 18 GA.
HI IDLE (-) H 1133 PK/BK 16 GA.
IGNITION J
K
L
IGNITION SWITCH M 1102 PK/BK 18 GA.
N
DRL P 1317 GY 18 GA.
ENGINE RUNNING R 1111 ENG RUN RD 18 GA.
S
STARTER SWITCH T 1001 YL 16 GA.
U
BRAKE SIGNAL (-) V 1701 LT BL 18 GA.
FAN RELAY (+) W FAN CL+ OR 18 GA.
FAN RELAY (-) X ECM RET WH 18 GA
11
11136A BK 12 GA.
1111L BK 12 GA.
11146E PK/BK 16 GA.
11136P PK/BK 16 GA.
11136G PK/BK 14 GA.
1168L PK/BK 14 GA.
1163 PK/BK 12 GA.
1181 PK/BK 12 GA.
1165D BK 16 GA.
FAN PWR RD 16 GA.
1165E BK 16 GA.
P1
1111 BK 12 GA.
11146 PK/BK 14 GA.
11136N PK/BK 14 GA.
1181A PK/BK 10 GA.
1181B PK/BK 10 GA.
1165BK 12 GA.
1182 14 GA. FUSIBLE LINK
MEGA FUSE 200A
F1
1183A BK 10 GA.
1183B BK 10 GA.
1 GA
LOAD
2/0



PDU, Cummins ISB-07, Air Brake, FE

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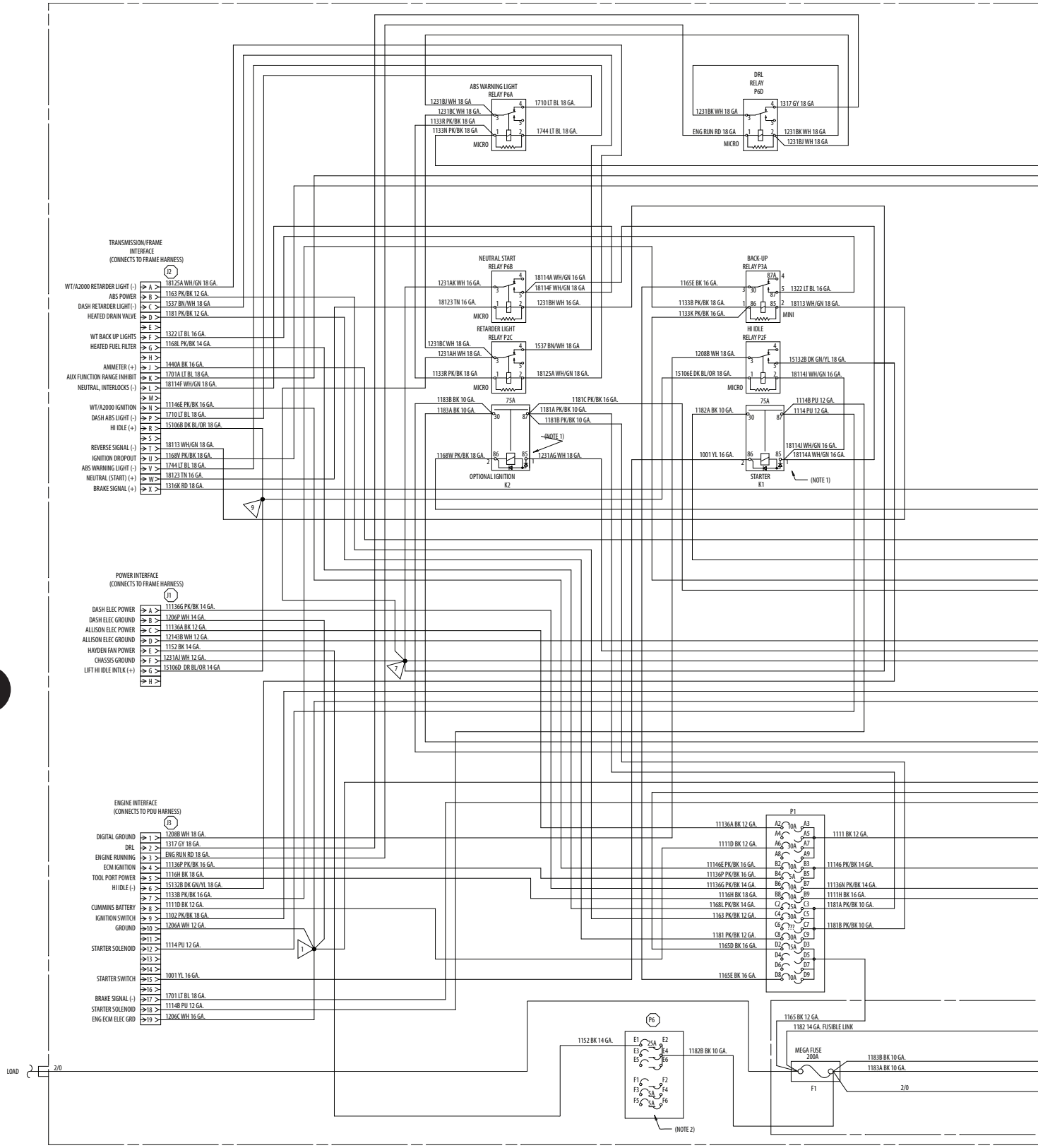
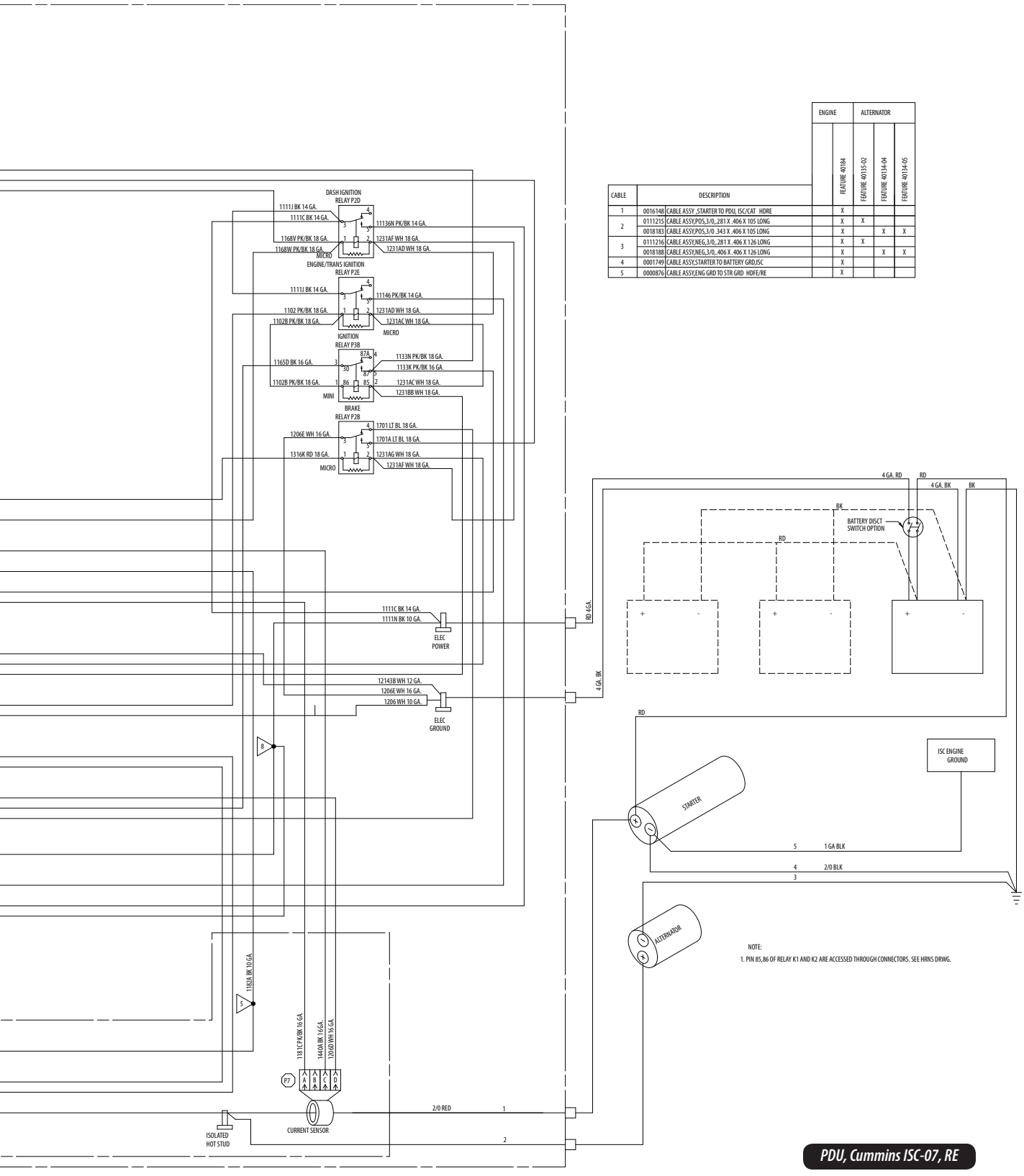

ABS WARNING LIGHT RELAY P6A
1231BJ WH 18 GA
1231BC WH 18 GA.
1133R PK/BK 18 GA
1133N PK/BK 18 GA
MICRO
1710 LT BL 18 GA.
1744 LT BL 18 GA.
DRL RELAY P6D
1231BK WH 18 GA
ENG RUN RD 18 GA
MICRO
1317 GY 18 GA
1231BK WH 18 GA
1231BJ WH 18 GA
TRANSMISSION/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
WT/A2000 RETARDER LIGHT (-)
ABS POWER
DASH RETARDER LIGHT(-)
HEATED DRAIN VALVE
WT BACK UP LIGHTS
HEATED FUEL FILTER
AMMETER (+)
AUX FUNCTION RANGE INHIBIT
NEUTRAL, INTERLOCKS (-)
WT/A2000 IGNITION
DASH ABS LIGHT (-)
HI IDLE (+)
REVERSE SIGNAL (-)
IGNITION DROPOUT
ABS WARNING LIGHT (-)
NEUTRAL (START) (+)
BRAKE SIGNAL (+)
18125A WH/GN 18 GA.
1163 PK/BK 12 GA.
1537 BN/WH 18 GA
1181 PK/BK 12 GA.
1322 LT BL 16 GA.
1168L PK/BK 14 GA.
1440A BK 16 GA.
1701A LT BL 18 GA.
18114F WH/GN 18 GA.
11146E PK/BK 16 GA.
1710 LT BL 18 GA.
15106B DK BL/OR 18 GA.
18113 WH/GN 18 GA.
1168V PK/BK 18 GA.
1744 LT BL 18 GA.
18123 TN 16 GA.
1316K RD 18 GA.
NEUTRAL START RELAY P6B
1231AK WH 16 GA.
18123 TN 16 GA.
MICRO
18114A WH/GN 16 GA
18114F WH/GN 18 GA
1231BH WH 16 GA.
18125A WH/GN 18 GA.
RETARDER LIGHT RELAY P2C
1231BC WH 18 GA.
1231AH WH 18 GA.
1133R PK/BK 18 GA
MICRO
1537 BN/WH 18 GA
1183B BK 10 GA.
1183A BK 10 GA.
1168W PK/BK 18 GA.
75A
30
87
86
85
2
1
1181C PK/BK 16 GA.
1181A PK/BK 10 GA.
1181B PK/BK 10 GA.
(NOTE 1)
1231AG WH 18 GA.
OPTIONAL IGNITION K2
BACK-UP RELAY P3A
1165E BK 16 GA.
1133B PK/BK 18 GA.
1133K PK/BK 16 GA.
87A
MINI
1322 LT BL 16 GA.
18113 WH/GN 18 GA.
HI IDLE RELAY P2F
1208B WH 18 GA.
15106E DK BL/OR 18 GA.
MICRO
15132B DK GN/YL 18 GA.
18114J WH/GN 16 GA.
1182A BK 10 GA.
1001 YL 16 GA.
1114B PU 12 GA.
1114 PU 12 GA.
18114J WH/GN 16 GA.
18114A WH/GN 16 GA.
STARTER K1
(NOTE 1)
9
POWER INTERFACE (CONNECTS TO FRAME HARNESS)
J1
DASH ELEC POWER
DASH ELEC GROUND
ALLISON ELEC POWER
ALLISON ELEC GROUND
HAYDEN FAN POWER
CHASSIS GROUND
LIFT HI IDLE INTLK (+)
11136G PK/BK 14 GA.
1206P WH 14 GA.
11136A BK 12 GA.
12143B WH 12 GA.
1152 BK 14 GA.
1231AJ WH 12 GA.
15106D DR BL/OR 14 GA
7
ENGINE INTERFACE (CONNECTS TO PDU HARNESS)
J3
DIGITAL GROUND
DRL
ENGINE RUNNING
ECM IGNITION
TOOL PORT POWER
HI IDLE (-)
CUMMINS BATTERY
IGNITION SWITCH
GROUND
STARTER SOLENOID
STARTER SWITCH
BRAKE SIGNAL (-)
STARTER SOLENOID
ENG ECM ELEC GRD
1208B WH 18 GA.
1317 GY 18 GA.
ENG RUN RD 18 GA.
11136P PK/BK 16 GA.
1116H BK 18 GA.
15132B DK GN/YL 18 GA.
1133B PK/BK 16 GA.
1111D BK 12 GA.
1102 PK/BK 18 GA.
1206A WH 12 GA.
1114 PU 12 GA.
1001 YL 16 GA.
1701 LT BL 18 GA.
1114B PU 12 GA.
1206C WH 16 GA.
1
P1
11136A BK 12 GA.
1111D BK 12 GA.
11146E PK/BK 16 GA.
11136P PK/BK 16 GA.
11136G PK/BK 14 GA.
1116H BK 18 GA.
1168L PK/BK 14 GA.
1163 PK/BK 12 GA.
1181 PK/BK 12 GA.
1165D BK 16 GA.
1165E BK 16 GA.
10A
30A
5A
7.5A
15A
1111 BK 12 GA.
11146 PK/BK 14 GA.
11136N PK/BK 14 GA.
1111H BK 16 GA.
1181A PK/BK 10 GA.
1181B PK/BK 10 GA.
P6
1152 BK 14 GA.
25A
5A
1182B BK 10 GA.
(NOTE 2)
1165 BK 12 GA.
1182 14 GA. FUSIBLE LINK
MEGA FUSE 200A
F1
1183B BK 10 GA.
1183A BK 10 GA.
2/0
LOAD
2/0

CABLE	DESCRIPTION		ENGINE	ALTERNATOR		
			FEATURE 40184	FEATURE 40135-02	FEATURE 40134-04	FEATURE 40134-05
1	0016148	CABLE ASSY ,STARTER TO PDU, ISC/CAT HDRE	X			
2	0111215	CABLE ASSY,POS,3/0,.281 X .406 X 105 LONG	X	X		
	0018183	CABLE ASSY,POS,3/0 .343 X .406 X 105 LONG	X		X	X
3	0111216	CABLE ASSY,NEG,3/0,.281 X .406 X 126 LONG	X	X		
	0018188	CABLE ASSY,NEG,3/0, .406 X .406 X 126 LONG	X		X	X
4	0001749	CABLE ASSY,STARTER TO BATTERY GRD,ISC	X			
5	0000876	CABLE ASSY,ENG GRD TO STR GRD HDFE/RE	X			



NOTE:

1. PIN 85,86 OF RELAY K1 AND K2 ARE ACCESSED THROUGH CONNECTORS. SEE HRNS DRWG.

PDU, Cummins ISC-07, RE

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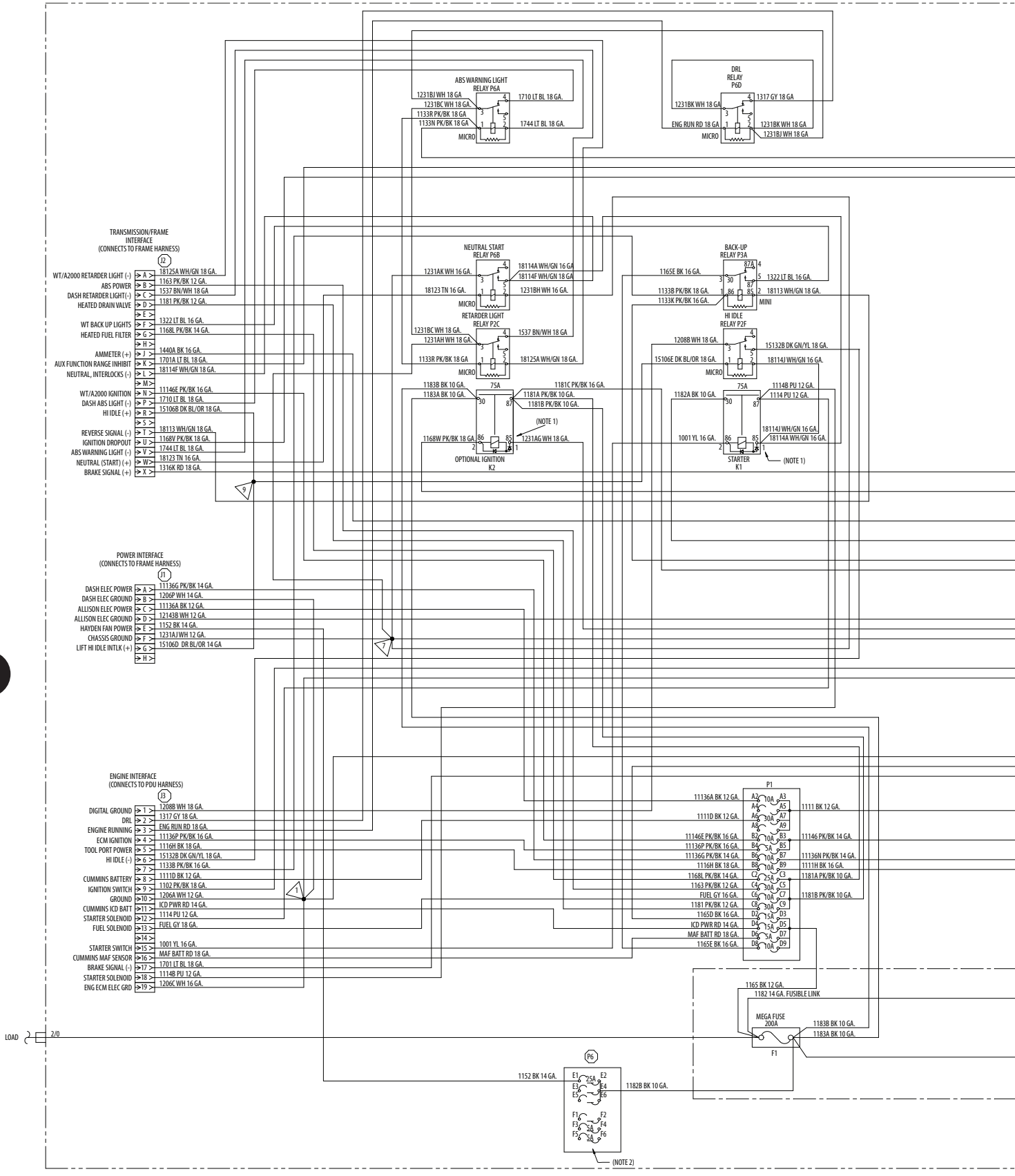
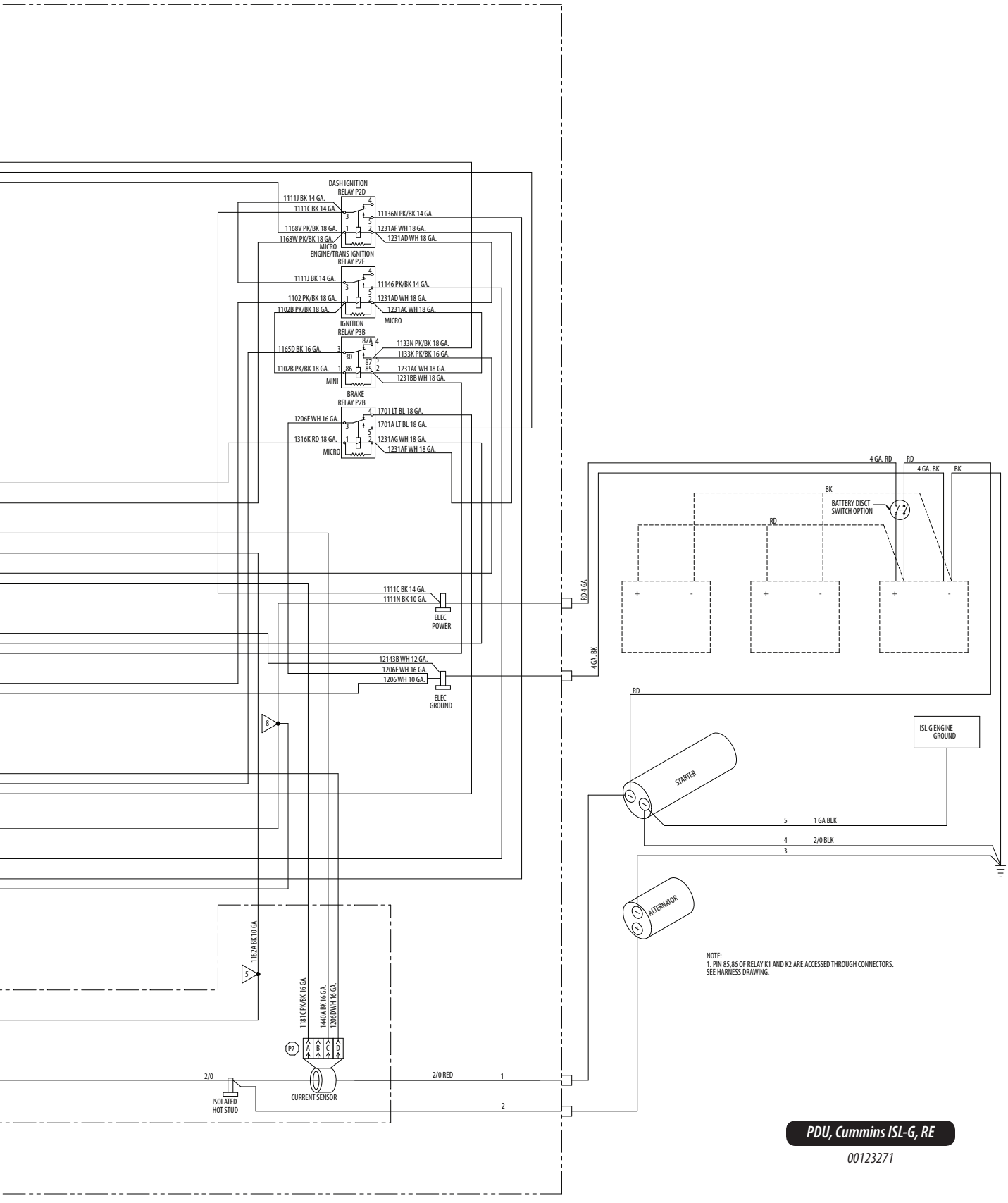

ABS WARNING LIGHT RELAY P6A
1231BJ WH 18 GA
1231BC WH 18 GA.
1133R PK/BK 18 GA
1133N PK/BK 18 GA
MICRO
1710 LT BL 18 GA.
1744 LT BL 18 GA.
DRL RELAY P6D
1231BK WH 18 GA
ENG RUN RD 18 GA
MICRO
1317 GY 18 GA
1231BK WH 18 GA
1231BJ WH 18 GA
TRANSMISSION/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
WT/A2000 RETARDER LIGHT (-) A 18125A WH/GN 18 GA.
ABS POWER B 1163 PK/BK 12 GA.
DASH RETARDER LIGHT(-) C 1537 BN/WH 18 GA
HEATED DRAIN VALVE D 1181 PK/BK 12 GA.
E
WT BACK UP LIGHTS F 1322 LT BL 16 GA.
HEATED FUEL FILTER G 1168L PK/BK 14 GA.
H
AMMETER (+) J 1440A BK 16 GA.
AUX FUNCTION RANGE INHIBIT K 1701A LT BL 18 GA.
NEUTRAL, INTERLOCKS (-) L 18114F WH/GN 18 GA.
M
WT/A2000 IGNITION N 11146E PK/BK 16 GA.
DASH ABS LIGHT (-) P 1710 LT BL 18 GA.
HI IDLE (+) R 15106B DK BL/OR 18 GA.
S
REVERSE SIGNAL (-) T 18113 WH/GN 18 GA.
IGNITION DROPOUT U 1168V PK/BK 18 GA.
ABS WARNING LIGHT (-) V 1744 LT BL 18 GA.
NEUTRAL (START) (+) W 18123 TN 16 GA.
BRAKE SIGNAL (+) X 1316K RD 18 GA.
9
NEUTRAL START RELAY P6B
1231AK WH 16 GA.
18123 TN 16 GA.
MICRO
18114A WH/GN 16 GA
18114F WH/GN 18 GA
1231BH WH 16 GA.
RETARDER LIGHT RELAY P2C
1231BC WH 18 GA.
1231AH WH 18 GA
1133R PK/BK 18 GA
MICRO
1537 BN/WH 18 GA
18125A WH/GN 18 GA.
1183B BK 10 GA.
1183A BK 10 GA.
75A
1181A PK/BK 10 GA.
1181B PK/BK 10 GA.
(NOTE 1)
1168W PK/BK 18 GA.
1231AG WH 18 GA.
OPTIONAL IGNITION K2
1181C PK/BK 16 GA.
BACK-UP RELAY P3A
1165E BK 16 GA.
1133B PK/BK 18 GA.
1133K PK/BK 16 GA.
MINI
1322 LT BL 16 GA.
18113 WH/GN 18 GA.
HI IDLE RELAY P2F
1208B WH 18 GA.
15106E DK BL/OR 18 GA.
MICRO
15132B DK GN/YL 18 GA.
18114J WH/GN 16 GA.
1182A BK 10 GA.
75A
1114B PU 12 GA.
1114 PU 12 GA.
1001 YL 16 GA.
18114J WH/GN 16 GA.
18114A WH/GN 16 GA.
STARTER K1
(NOTE 1)
POWER INTERFACE (CONNECTS TO FRAME HARNESS)
J1
DASH ELEC POWER A 11136G PK/BK 14 GA.
DASH ELEC GROUND B 1206P WH 14 GA.
ALLISON ELEC POWER C 11136A BK 12 GA.
ALLISON ELEC GROUND D 12143B WH 12 GA.
HAYDEN FAN POWER E 1152 BK 14 GA.
CHASSIS GROUND F 1231AJ WH 12 GA.
LIFT HI IDLE INTLK (+) G 15106D DR BL/OR 14 GA
H
7
ENGINE INTERFACE (CONNECTS TO PDU HARNESS)
J3
DIGITAL GROUND 1 1208B WH 18 GA.
DRL 2 1317 GY 18 GA.
ENGINE RUNNING 3 ENG RUN RD 18 GA.
ECM IGNITION 4 11136P PK/BK 16 GA.
TOOL PORT POWER 5 1116H BK 18 GA.
HI IDLE (-) 6 15132B DK GN/YL 18 GA.
7 1133B PK/BK 16 GA.
CUMMINS BATTERY 8 1111D BK 12 GA.
IGNITION SWITCH 9 1102 PK/BK 18 GA.
GROUND 10 1206A WH 12 GA.
CUMMINS ICD BATT 11 ICD PWR RD 14 GA.
STARTER SOLENOID 12 1114 PU 12 GA.
FUEL SOLENOID 13 FUEL GY 18 GA.
14 1001 YL 16 GA.
STARTER SWITCH 15 MAF BATT RD 18 GA.
CUMMINS MAF SENSOR 16 1701 LT BL 18 GA.
BRAKE SIGNAL (-) 17 1114B PU 12 GA.
STARTER SOLENOID 18 1206C WH 16 GA.
ENG ECM ELEC GRD 19
1
P1
11136A BK 12 GA.
1111D BK 12 GA.
11146E PK/BK 16 GA.
11136P PK/BK 16 GA.
11136G PK/BK 14 GA.
1116H BK 18 GA.
1168L PK/BK 14 GA.
1163 PK/BK 12 GA.
FUEL GY 16 GA.
1181 PK/BK 12 GA.
1165D BK 16 GA.
ICD PWR RD 14 GA.
MAF BATT RD 18 GA.
1165E BK 16 GA.
A2 10A A3
A4 A5 1111 BK 12 GA.
A6 30A A7
A8 A9
B2 10A B3 11146 PK/BK 14 GA.
B4 5A B5
B6 10A B7 11136N PK/BK 14 GA.
B8 10A B9 1111H BK 16 GA.
C2 5A C3 1181A PK/BK 10 GA.
C4 30A C5
C6 10A C7 1181B PK/BK 10 GA.
C8 30A C9
D2 15A D3
D4 15A D5
D6 5A D7
D8 10A D9
1165 BK 12 GA.
1182 14 GA. FUSIBLE LINK
MEGA FUSE 200A
F1
1183B BK 10 GA.
1183A BK 10 GA.
LOAD
2/0
P6
1152 BK 14 GA.
1182B BK 10 GA.
E1 25A E2
E3 E4
E5 E6
F1 F2
F3 20A F4
F5 20A F6
(NOTE 2)



NOTE:
1. PIN 85,86 OF RELAY K1 AND K2 ARE ACCESSED THROUGH CONNECTORS. SEE HARNESS DRAWING.

PDU, Cummins ISL-G, RE

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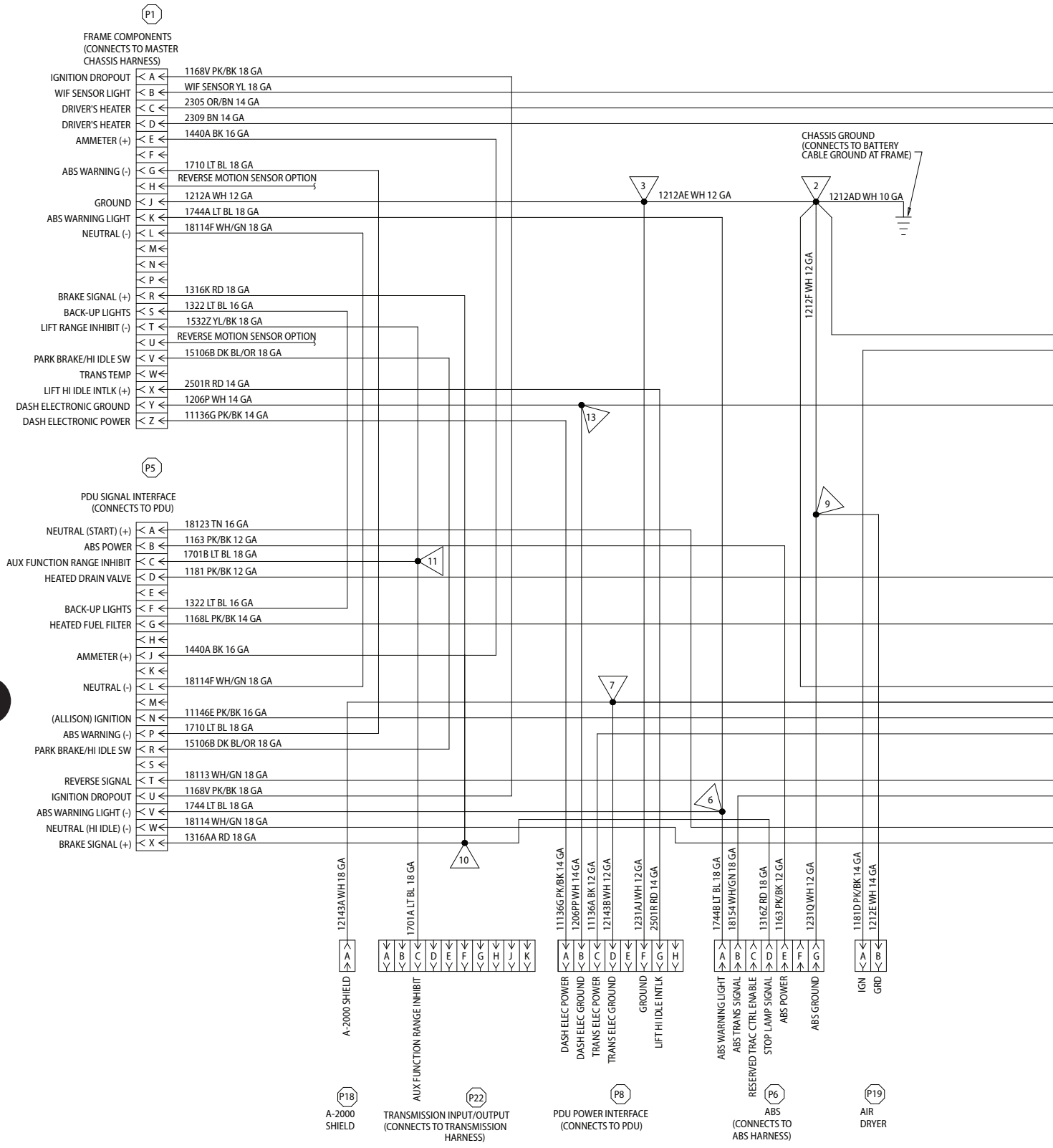
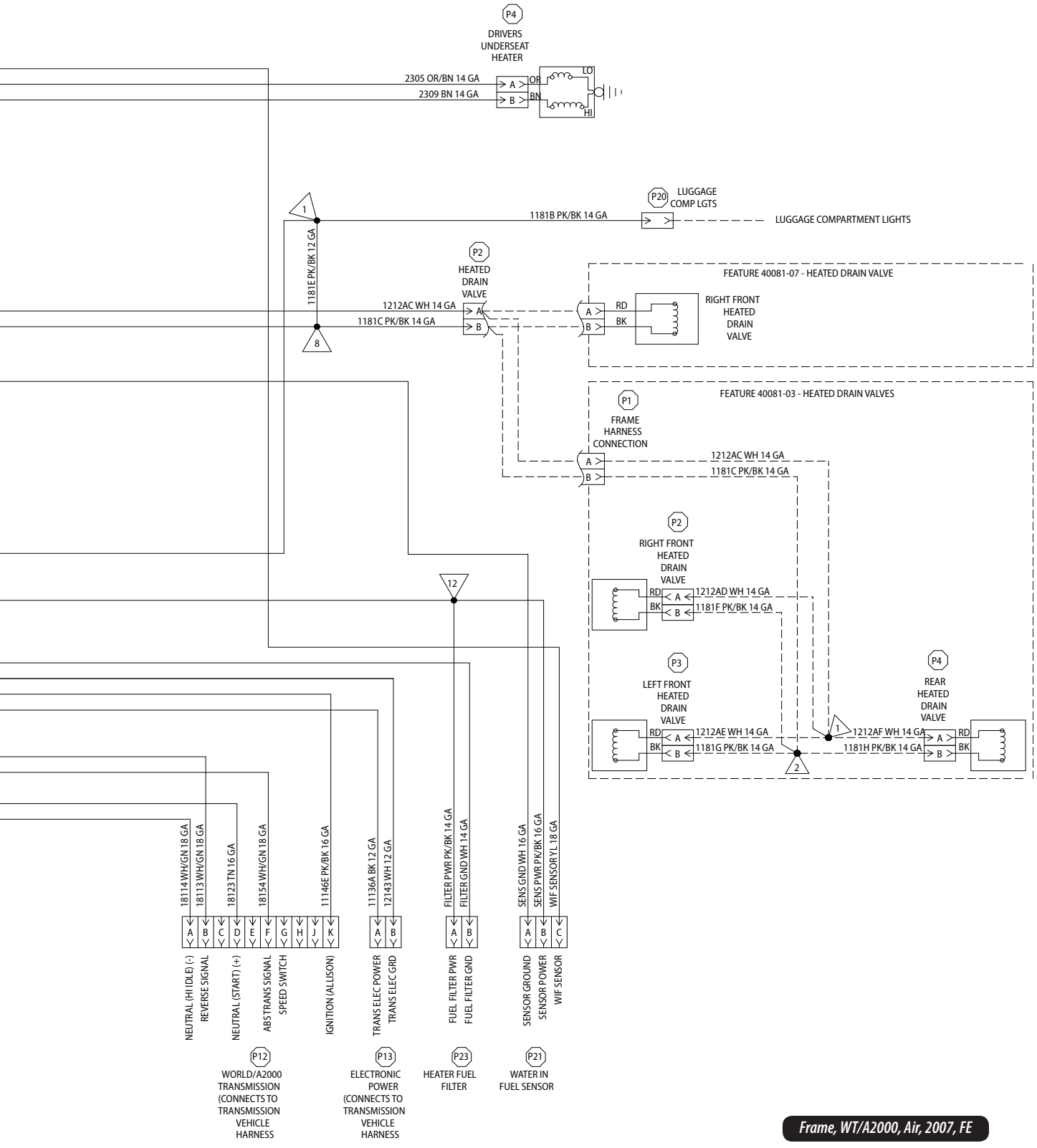

P1
FRAME COMPONENTS (CONNECTS TO MASTER CHASSIS HARNESS)
IGNITION DROPOUT A
WIF SENSOR LIGHT B
DRIVER'S HEATER C
DRIVER'S HEATER D
AMMETER (+) E
F
ABS WARNING (-) G
H
GROUND J
ABS WARNING LIGHT K
NEUTRAL (-) L
M
N
P
BRAKE SIGNAL (+) R
BACK-UP LIGHTS S
LIFT RANGE INHIBIT (-) T
U
PARK BRAKE/HI IDLE SW V
TRANS TEMP W
LIFT HI IDLE INTLK (+) X
DASH ELECTRONIC GROUND Y
DASH ELECTRONIC POWER Z
1168V PK/BK 18 GA
WIF SENSOR YL 18 GA
2305 OR/BN 14 GA
2309 BN 14 GA
1440A BK 16 GA
1710 LT BL 18 GA
REVERSE MOTION SENSOR OPTION
1212A WH 12 GA
1744A LT BL 18 GA
18114F WH/GN 18 GA
1316K RD 18 GA
1322 LT BL 16 GA
1532Z YL/BK 18 GA
REVERSE MOTION SENSOR OPTION
15106B DK BL/OR 18 GA
2501R RD 14 GA
1206P WH 14 GA
11136G PK/BK 14 GA
CHASSIS GROUND (CONNECTS TO BATTERY CABLE GROUND AT FRAME)
1212AE WH 12 GA
1212AD WH 10 GA
1212F WH 12 GA
P5
PDU SIGNAL INTERFACE (CONNECTS TO PDU)
NEUTRAL (START) (+) A
ABS POWER B
AUX FUNCTION RANGE INHIBIT C
HEATED DRAIN VALVE D
E
BACK-UP LIGHTS F
HEATED FUEL FILTER G
H
AMMETER (+) J
K
NEUTRAL (-) L
M
(ALLISON) IGNITION N
ABS WARNING (-) P
PARK BRAKE/HI IDLE SW R
S
REVERSE SIGNAL T
IGNITION DROPOUT U
ABS WARNING LIGHT (-) V
NEUTRAL (HI IDLE) (-) W
BRAKE SIGNAL (+) X
18123 TN 16 GA
1163 PK/BK 12 GA
1701B LT BL 18 GA
1181 PK/BK 12 GA
1322 LT BL 16 GA
1168L PK/BK 14 GA
1440A BK 16 GA
18114F WH/GN 18 GA
11146E PK/BK 16 GA
1710 LT BL 18 GA
15106B DK BL/OR 18 GA
18113 WH/GN 18 GA
1168V PK/BK 18 GA
1744 LT BL 18 GA
18114 WH/GN 18 GA
1316AA RD 18 GA
12143A WH 18 GA
1701A LT BL 18 GA
11136G PK/BK 14 GA
1206PP WH 14 GA
11136A BK 12 GA
12143B WH 12 GA
1231AJ WH 12 GA
2501R RD 14 GA
1744B LT BL 18 GA
18154 WH/GN 18 GA
1316Z RD 18 GA
1163 PK/BK 12 GA
1231Q WH 12 GA
1181D PK/BK 14 GA
1212E WH 14 GA
A-2000 SHIELD
AUX FUNCTION RANGE INHIBIT
DASH ELEC POWER
DASH ELEC GROUND
TRANS ELEC POWER
TRANS ELEC GROUND
GROUND
LIFT HI IDLE INTLK
ABS WARNING LIGHT
ABS TRANS SIGNAL
RESERVED TRAC CTRL ENABLE
STOP LAMP SIGNAL
ABS POWER
ABS GROUND
IGN
GRD
P18 A-2000 SHIELD
P22 TRANSMISSION INPUT/OUTPUT (CONNECTS TO TRANSMISSION HARNESS)
P8 PDU POWER INTERFACE (CONNECTS TO PDU)
P6 ABS (CONNECTS TO ABS HARNESS)
P19 AIR DRYER



Frame, WT/A2000, Air, 2007, FE

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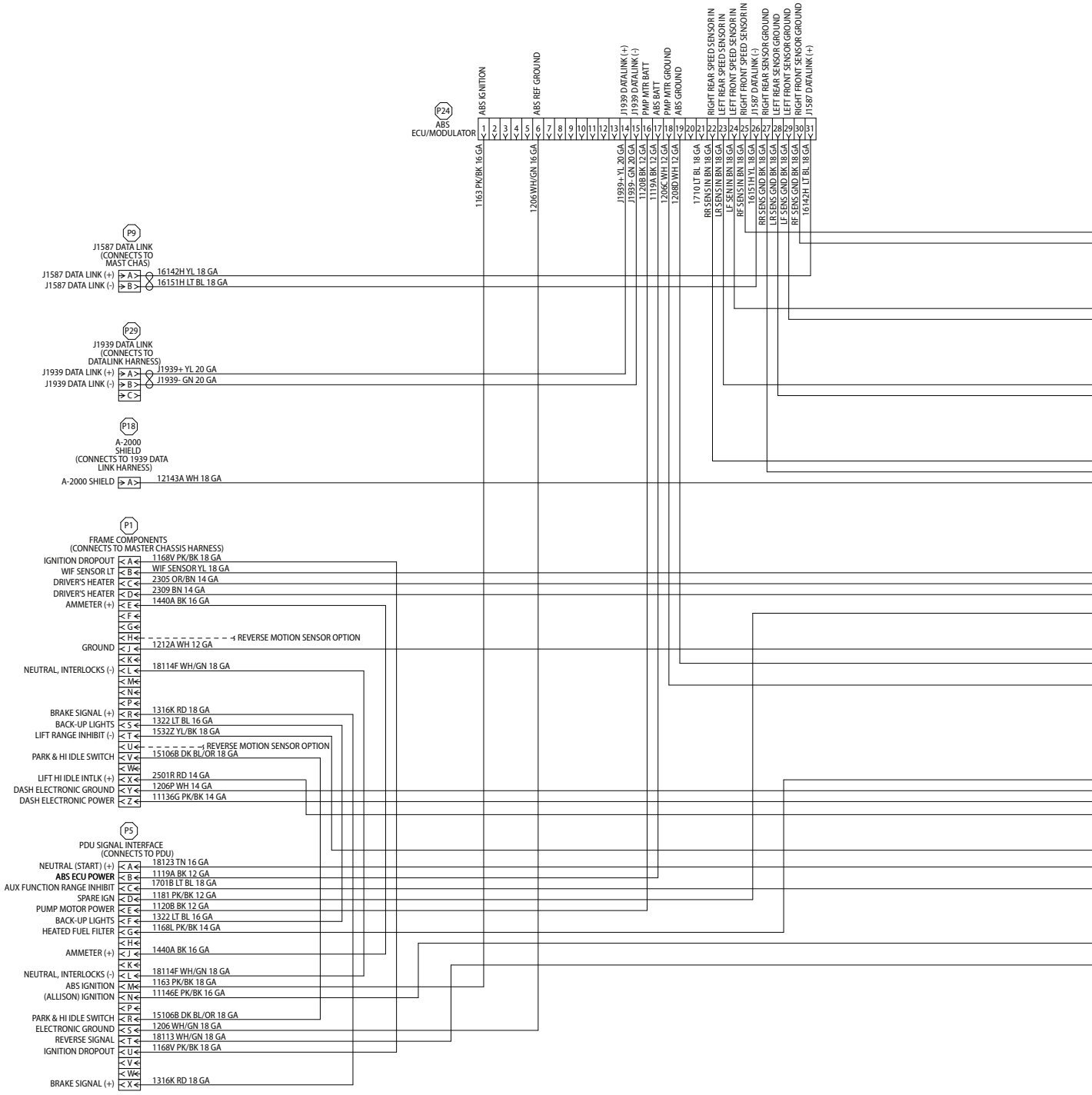
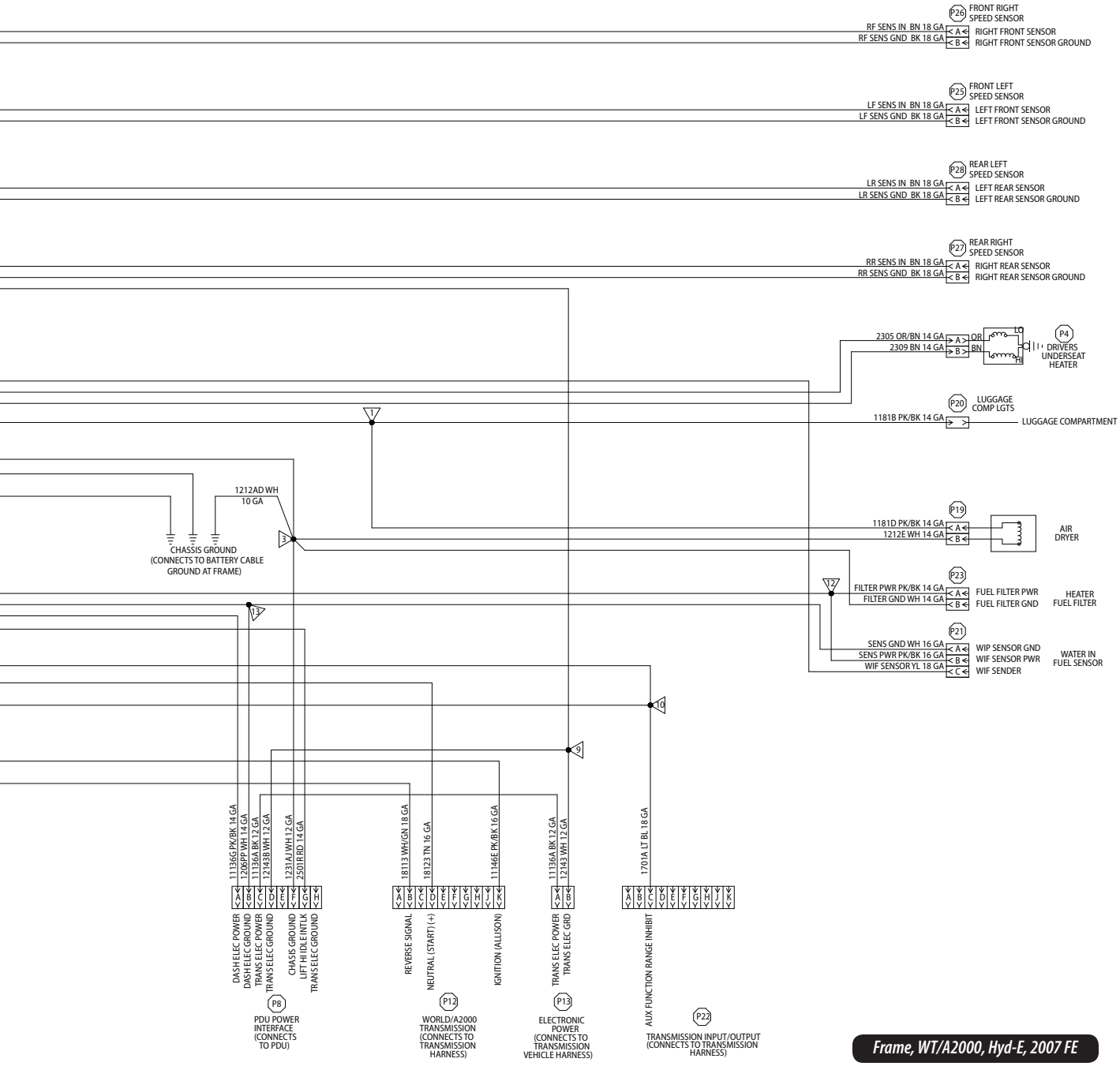
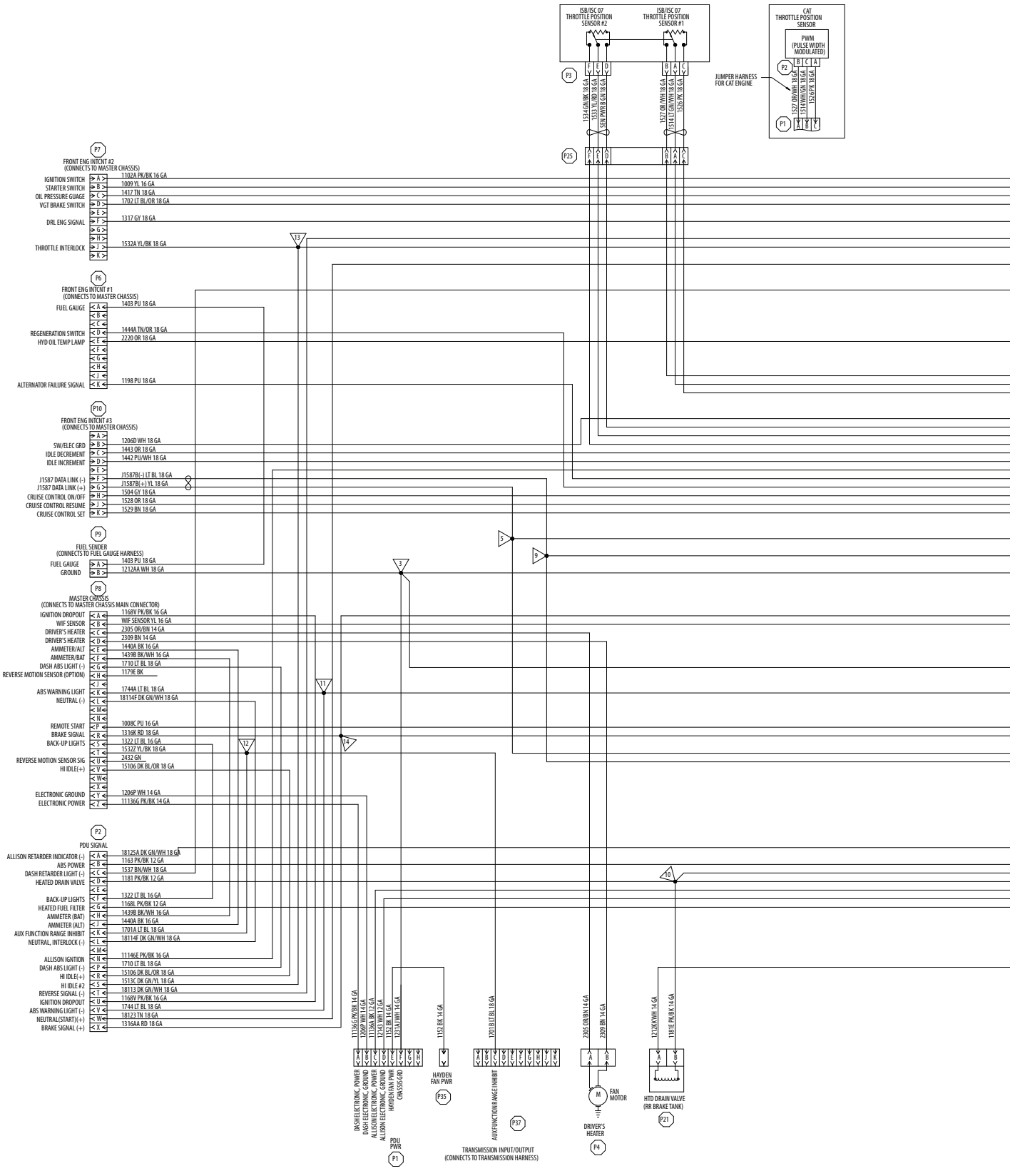
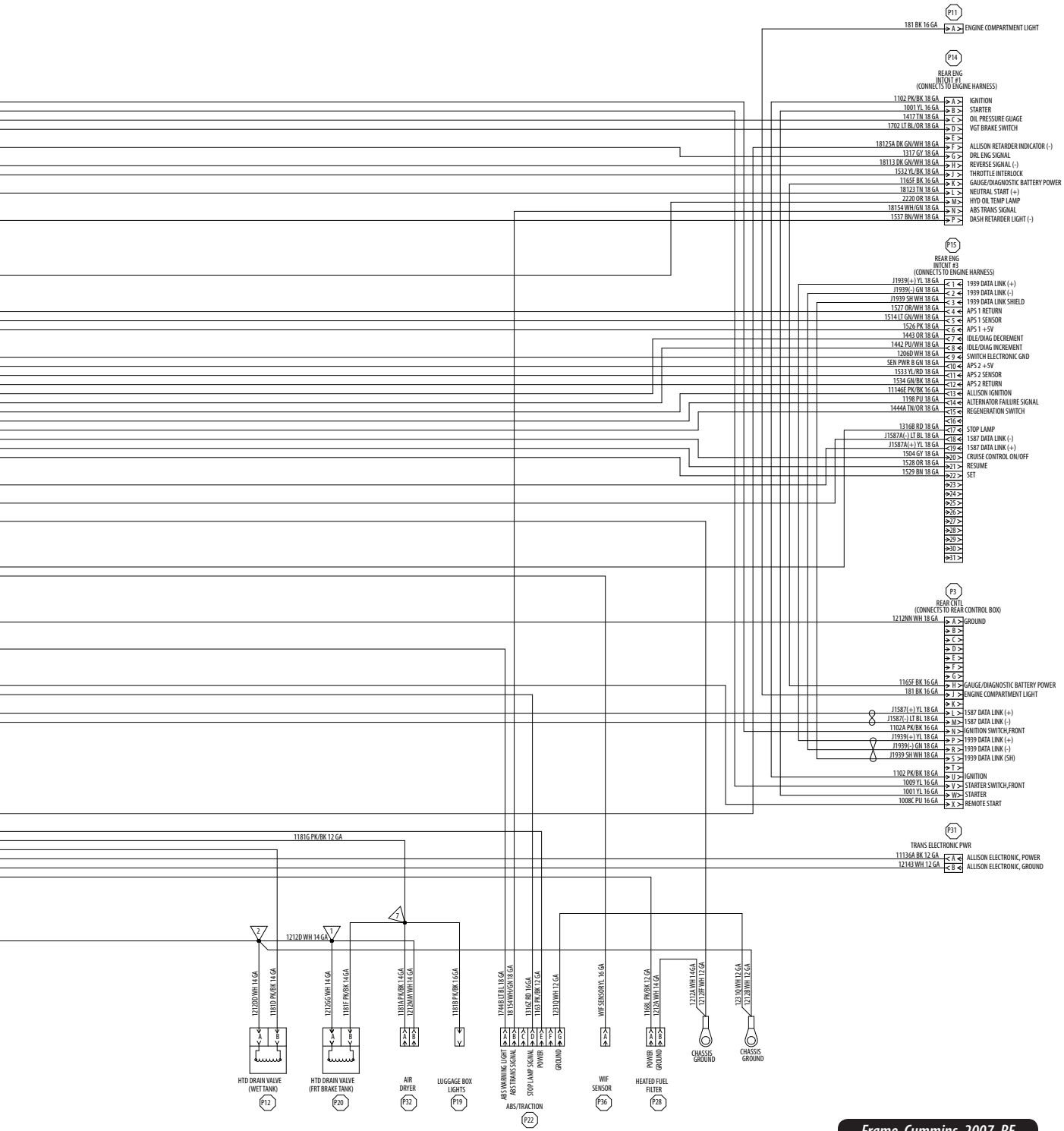

P24
ABS ECU/MODULATOR
1 ABS IGNITION 1163 PK/BK 16 GA
6 ABS REF GROUND 1206 WH/GN 16 GA
14 J1939 DATALINK (+) J1939+ YL 20 GA
15 J1939 DATALINK (-) J1939- GN 20 GA
16 PMP MTR BATT 1120B BK 12 GA
17 ABS BATT 1119A BK 12 GA
18 PMP MTR GROUND 1206C WH 12 GA
19 ABS GROUND 1208D WH 12 GA
20 1710 LT BL 18 GA
22 RIGHT REAR SPEED SENSOR IN RR SENS IN BN 18 GA
23 LEFT REAR SPEED SENSOR IN LR SENS IN BN 18 GA
24 LEFT FRONT SPEED SENSOR IN LF SENS IN BN 18 GA
25 RIGHT FRONT SPEED SENSOR IN RF SENS IN BN 18 GA
26 J1587 DATALINK (-) 16151H YL 18 GA
27 RIGHT REAR SENSOR GROUND RR SENS GND BK 18 GA
28 LEFT REAR SENSOR GROUND LR SENS GND BK 18 GA
29 LEFT FRONT SENSOR GROUND LF SENS GND BK 18 GA
30 RIGHT FRONT SENSOR GROUND RF SENS GND BK 18 GA
31 J1587 DATALINK (+) 16142H LT BL 18 GA
P9
J1587 DATA LINK (CONNECTS TO MAST CHAS)
J1587 DATA LINK (+) A 16142H YL 18 GA
J1587 DATA LINK (-) B 16151H LT BL 18 GA
P29
J1939 DATA LINK (CONNECTS TO DATALINK HARNESS)
J1939 DATA LINK (+) A J1939+ YL 20 GA
J1939 DATA LINK (-) B J1939- GN 20 GA
C
P18
A-2000 SHIELD (CONNECTS TO 1939 DATA LINK HARNESS)
A-2000 SHIELD A 12143A WH 18 GA
P1
FRAME COMPONENTS (CONNECTS TO MASTER CHASSIS HARNESS)
IGNITION DROPOUT A 1168V PK/BK 18 GA
WIF SENSOR LT B WIF SENSOR YL 18 GA
DRIVER'S HEATER C 2305 OR/BN 14 GA
DRIVER'S HEATER D 2309 BN 14 GA
AMMETER (+) E 1440A BK 16 GA
F
G
H REVERSE MOTION SENSOR OPTION
GROUND J 1212A WH 12 GA
K
NEUTRAL, INTERLOCKS (-) L 18114F WH/GN 18 GA
M
N
P
BRAKE SIGNAL (+) R 1316K RD 18 GA
BACK-UP LIGHTS S 1322 LT BL 16 GA
LIFT RANGE INHIBIT (-) T 1532Z YL/BK 18 GA
U REVERSE MOTION SENSOR OPTION
PARK & HI IDLE SWITCH V 15106B DK BL/OR 18 GA
W
LIFT HI IDLE INTLK (+) X 2501R RD 14 GA
DASH ELECTRONIC GROUND Y 1206P WH 14 GA
DASH ELECTRONIC POWER Z 11136G PK/BK 14 GA
P5
PDU SIGNAL INTERFACE (CONNECTS TO PDU)
NEUTRAL (START) (+) A 18123 TN 16 GA
ABS ECU POWER B 1119A BK 12 GA
AUX FUNCTION RANGE INHIBIT C 1701B LT BL 18 GA
SPARE IGN D 1181 PK/BK 12 GA
PUMP MOTOR POWER E 1120B BK 12 GA
BACK-UP LIGHTS F 1322 LT BL 16 GA
HEATED FUEL FILTER G 1168L PK/BK 14 GA
H
AMMETER (+) J 1440A BK 16 GA
K
NEUTRAL, INTERLOCKS (-) L 18114F WH/GN 18 GA
ABS IGNITION M 1163 PK/BK 18 GA
(ALLISON) IGNITION N 11146E PK/BK 16 GA
P
PARK & HI IDLE SWITCH R 15106B DK BL/OR 18 GA
ELECTRONIC GROUND S 1206 WH/GN 18 GA
REVERSE SIGNAL T 18113 WH/GN 18 GA
IGNITION DROPOUT U 1168V PK/BK 18 GA
V
W
BRAKE SIGNAL (+) X 1316K RD 18 GA



Frame, WT/A2000, Hyd-E, 2007 FE

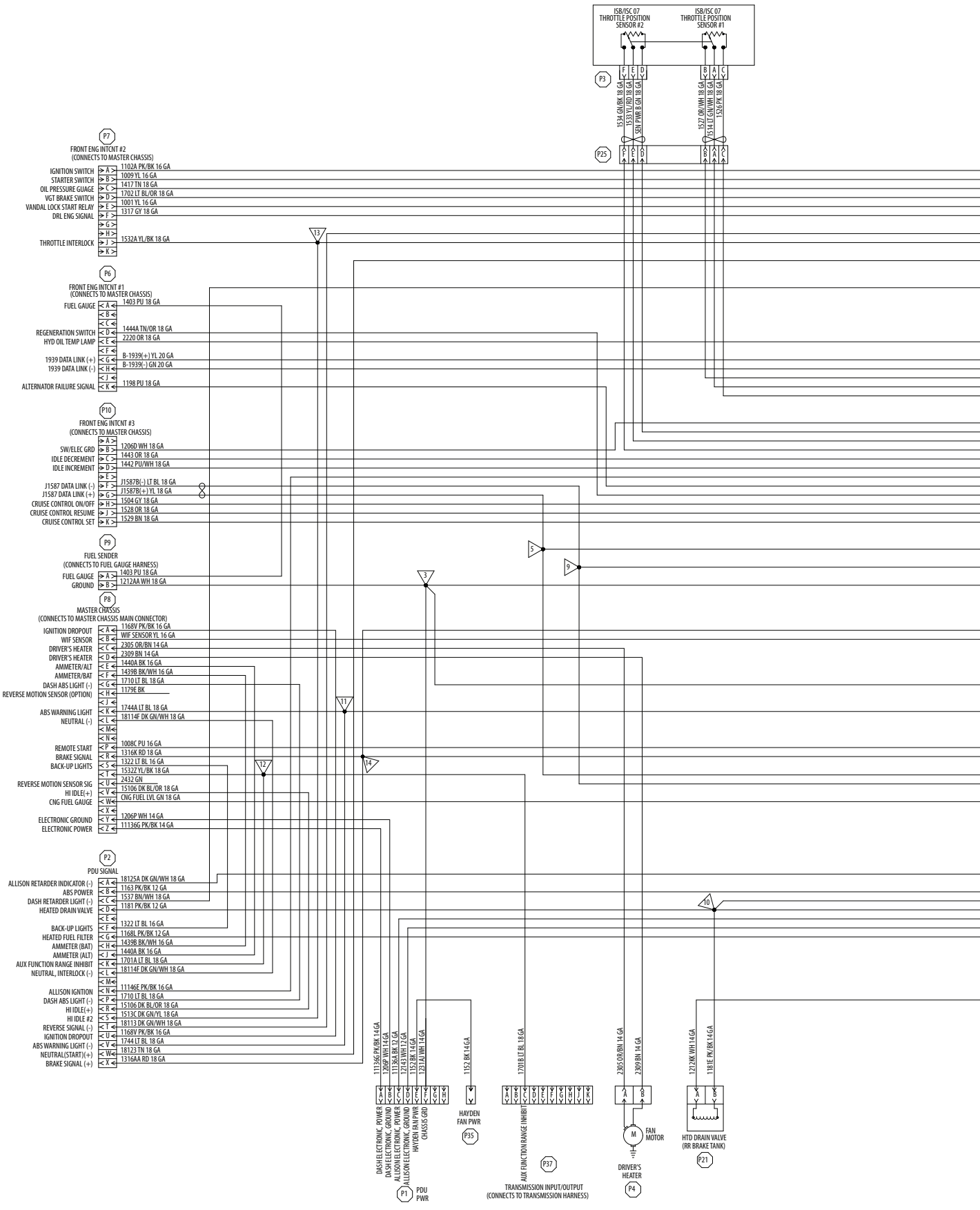
0117373B

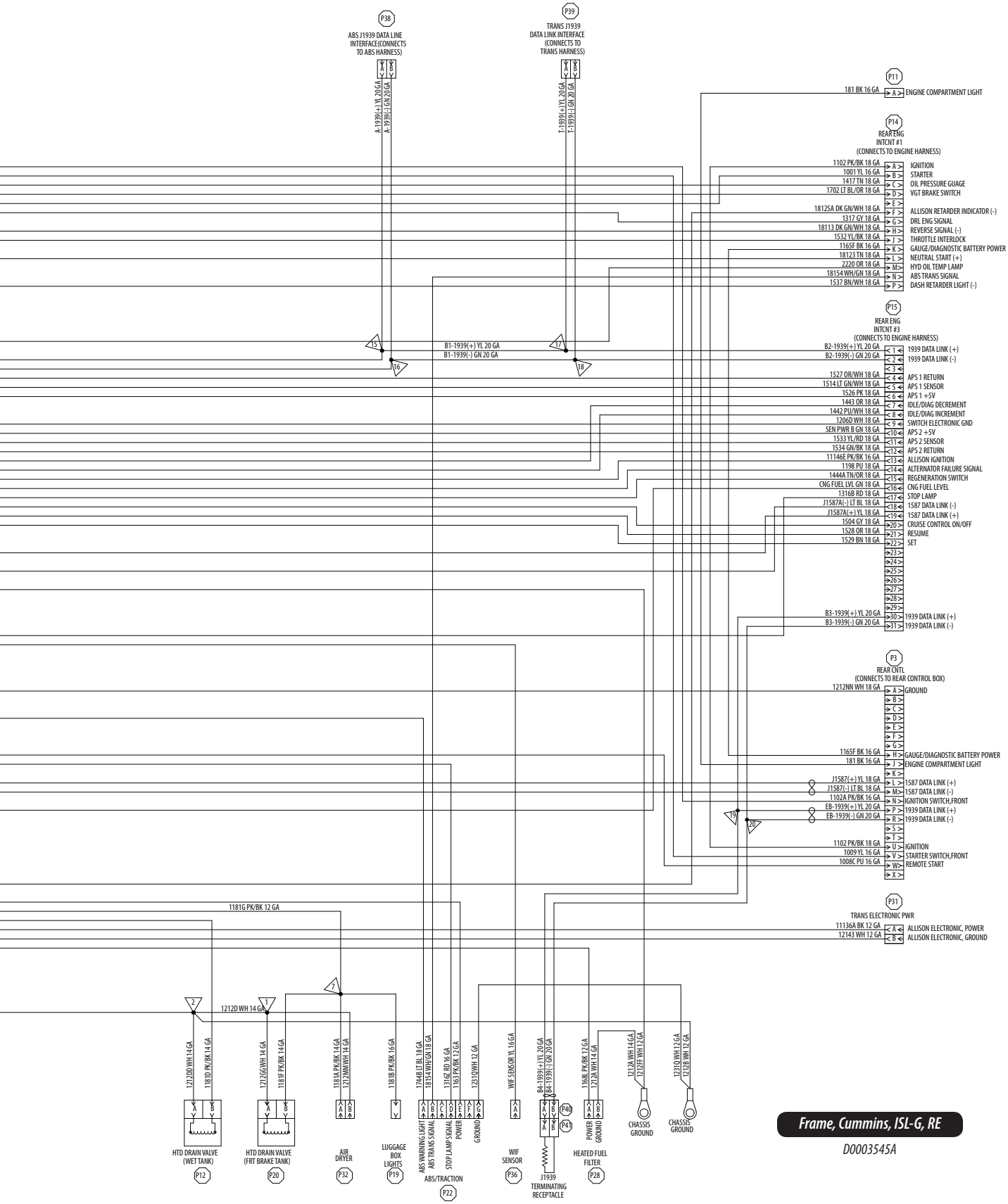

ISB/ISC 07 THROTTLE POSITION SENSOR #2
ISB/ISC 07 THROTTLE POSITION SENSOR #1
CAT THROTTLE POSITION SENSOR
PWM (PULSE WIDTH MODULATED)
JUMPER HARNESS FOR CAT ENGINE
P3
P25
P2
P1
P7
FRONT ENG INTCNT #2 (CONNECTS TO MASTER CHASSIS)
IGNITION SWITCH 1102A PK/BK 16 GA
STARTER SWITCH 1009 YL 16 GA
OIL PRESSURE GUAGE 1417 TN 18 GA
VGT BRAKE SWITCH 1702 LT BL/OR 18 GA
DRL ENG SIGNAL 1317 GY 18 GA
THROTTLE INTERLOCK 1532A YL/BK 18 GA
P6
FRONT ENG INTCNT #1 (CONNECTS TO MASTER CHASSIS)
FUEL GAUGE 1403 PU 18 GA
REGENERATION SWITCH 1444A TN/OR 18 GA
HYD OIL TEMP LAMP 2220 OR 18 GA
ALTERNATOR FAILURE SIGNAL 1198 PU 18 GA
P10
FRONT ENG INTCNT #3 (CONNECTS TO MASTER CHASSIS)
SW/ELEC GRD 1206D WH 18 GA
IDLE DECREMENT 1443 OR 18 GA
IDLE INCREMENT 1442 PU/WH 18 GA
J1587 DATA LINK (-) J1587B(-) LT BL 18 GA
J1587 DATA LINK (+) J1587B(+) YL 18 GA
CRUISE CONTROL ON/OFF 1504 GY 18 GA
CRUISE CONTROL RESUME 1528 OR 18 GA
CRUISE CONTROL SET 1529 BN 18 GA
P9
FUEL SENDER (CONNECTS TO FUEL GAUGE HARNESS)
FUEL GAUGE 1403 PU 18 GA
GROUND 1212AA WH 18 GA
P8
MASTER CHASSIS (CONNECTS TO MASTER CHASSIS MAIN CONNECTOR)
IGNITION DROPOUT 1168V PK/BK 16 GA
WIF SENSOR WIF SENSOR YL 16 GA
DRIVER'S HEATER 2305 OR/BN 14 GA
DRIVER'S HEATER 2309 BN 14 GA
AMMETER/ALT 1440A BK 16 GA
AMMETER/BAT 1439B BK/WH 16 GA
DASH ABS LIGHT (-) 1710 LT BL 18 GA
REVERSE MOTION SENSOR (OPTION) 1179E BK
ABS WARNING LIGHT 1744A LT BL 18 GA
NEUTRAL (-) 18114F DK GN/WH 18 GA
REMOTE START 1008C PU 16 GA
BRAKE SIGNAL 1316K RD 18 GA
BACK-UP LIGHTS 1322 LT BL 16 GA
1532Z YL/BK 18 GA
REVERSE MOTION SENSOR SIG 2432 GN
HI IDLE(+) 15106 DK BL/OR 18 GA
ELECTRONIC GROUND 1206P WH 14 GA
ELECTRONIC POWER 11136G PK/BK 14 GA
P2
PDU SIGNAL
ALLISON RETARDER INDICATOR (-) 18125A DK GN/WH 18 GA
ABS POWER 1163 PK/BK 12 GA
DASH RETARDER LIGHT (-) 1537 BN/WH 18 GA
HEATED DRAIN VALVE 1181 PK/BK 12 GA
BACK-UP LIGHTS 1322 LT BL 16 GA
HEATED FUEL FILTER 1168L PK/BK 12 GA
AMMETER (BAT) 1439B BK/WH 16 GA
AMMETER (ALT) 1440A BK 16 GA
AUX FUNCTION RANGE INHIBIT 1701A LT BL 18 GA
NEUTRAL, INTERLOCK (-) 18114F DK GN/WH 18 GA
ALLISON IGNITION 11146E PK/BK 16 GA
DASH ABS LIGHT (-) 1710 LT BL 18 GA
HI IDLE(+) 15106 DK BL/OR 18 GA
HI IDLE #2 1513C DK GN/YL 18 GA
REVERSE SIGNAL (-) 18113 DK GN/WH 18 GA
IGNITION DROPOUT 1168V PK/BK 16 GA
ABS WARNING LIGHT (-) 1744 LT BL 18 GA
NEUTRAL/START(+) 18123 TN 18 GA
BRAKE SIGNAL (+) 1316AA RD 18 GA
11136G PK/BK 14 GA
1206P WH 14 GA
11136G PK/BK 14 GA
1216D WH 17 GA
1152 BK 14 GA
1233A WH 14 GA
DASH ELECTRONIC POWER
DASH ELECTRONIC GROUND
ALLISON ELECTRONIC POWER
ALLISON ELECTRONIC GROUND
HOT IN START/RUN
CHASSIS GRD
PDU PWR
P1
1152 BK 14 GA
HAYDEN FAN PWR
P35
1701B LT BL 18 GA
AUX FUNCTION RANGE INHIBIT
P37
TRANSMISSION INPUT/OUTPUT (CONNECTS TO TRANSMISSION HARNESS)
2305 OR/BN 14 GA
2309 BN 14 GA
FAN MOTOR
DRIVER'S HEATER
P4
1212K WH 16 GA
1181E PK/BK 14 GA
HTD DRAIN VALVE (RR BRAKE TANK)
P21



Frame, Cummins, 2007, RE

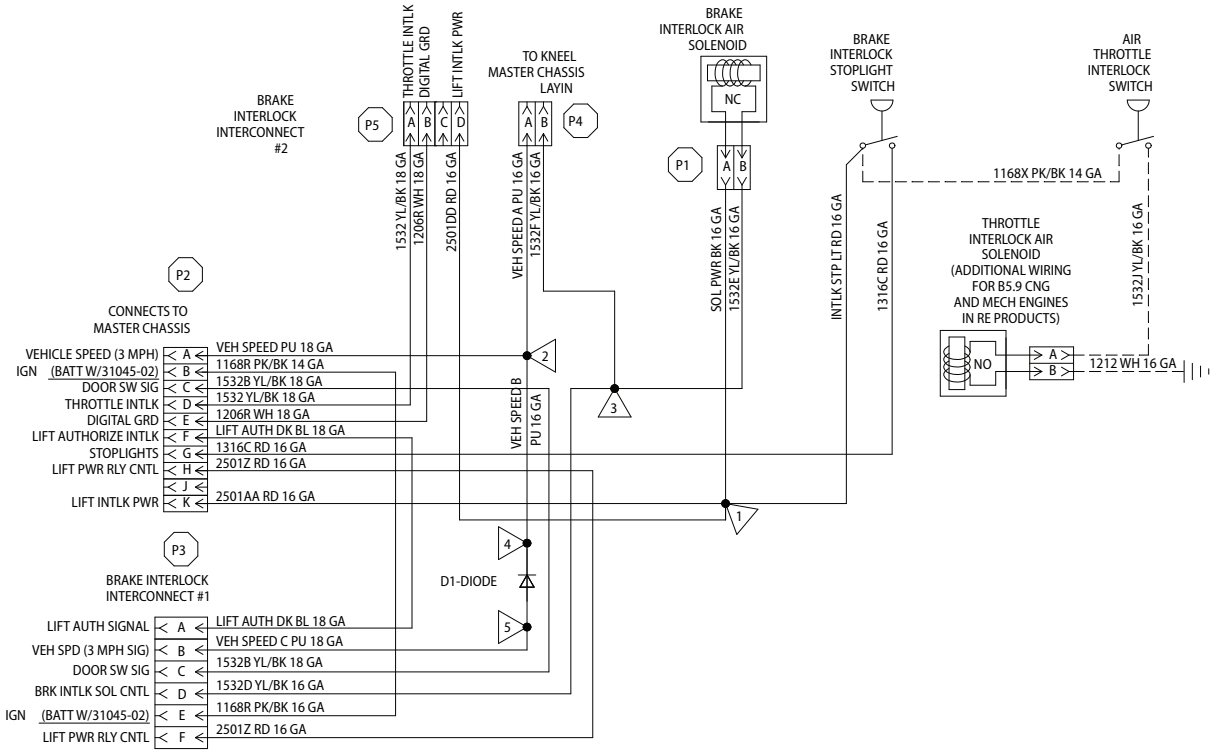
0105852


ISB/ISC 07 THROTTLE POSITION SENSOR #2
ISB/ISC 07 THROTTLE POSITION SENSOR #1
P3
P25
1534 GN/BK 18 GA
1533 YL/RD 18 GA
SBN PWR B GN 18 GA
1527 OR/WH 18 GA
1514 LT GN/WH 18 GA
1526 PK 18 GA
P7
FRONT ENG INTCNT #2
(CONNECTS TO MASTER CHASSIS)
IGNITION SWITCH 1102A PK/BK 16 GA
STARTER SWITCH 1009 YL 16 GA
OIL PRESSURE GUAGE 1417 TN 18 GA
VGT BRAKE SWITCH 1702 LT BL/OR 18 GA
VANDAL LOCK START RELAY 1001 YL 16 GA
DRL ENG SIGNAL 1317 GY 18 GA
THROTTLE INTERLOCK 1532A YL/BK 18 GA
P6
FRONT ENG INTCNT #1
(CONNECTS TO MASTER CHASSIS)
FUEL GAUGE 1403 PU 18 GA
REGENERATION SWITCH 1444A TN/OR 18 GA
HYD OIL TEMP LAMP 2220 OR 18 GA
1939 DATA LINK (+) B-1939(+) YL 20 GA
1939 DATA LINK (-) B-1939(-) GN 20 GA
ALTERNATOR FAILURE SIGNAL 1198 PU 18 GA
P10
FRONT ENG INTCNT #3
(CONNECTS TO MASTER CHASSIS)
SW/ELEC GRD 1206D WH 18 GA
IDLE DECREMENT 1443 OR 18 GA
IDLE INCREMENT 1442 PU/WH 18 GA
J1587 DATA LINK (-) J1587B(-) LT BL 18 GA
J1587 DATA LINK (+) J1587B(+) YL 18 GA
CRUISE CONTROL ON/OFF 1504 GY 18 GA
CRUISE CONTROL RESUME 1528 OR 18 GA
CRUISE CONTROL SET 1529 BN 18 GA
P9
FUEL SENDER
(CONNECTS TO FUEL GAUGE HARNESS)
FUEL GAUGE 1403 PU 18 GA
GROUND 1212AA WH 18 GA
P8
MASTER CHASSIS
(CONNECTS TO MASTER CHASSIS MAIN CONNECTOR)
IGNITION DROPOUT 1168V PK/BK 16 GA
WIF SENSOR WIF SENSOR YL 16 GA
DRIVER'S HEATER 2305 OR/BN 14 GA
DRIVER'S HEATER 2309 BN 14 GA
AMMETER/ALT 1440A BK 16 GA
AMMETER/BAT 1439B BK/WH 16 GA
DASH ABS LIGHT (-) 1710 LT BL 18 GA
REVERSE MOTION SENSOR (OPTION) 1179E BK
ABS WARNING LIGHT 1744A LT BL 18 GA
NEUTRAL (-) 18114F DK GN/WH 18 GA
REMOTE START 1008C PU 16 GA
BRAKE SIGNAL 1316K RD 18 GA
BACK-UP LIGHTS 1322 LT BL 16 GA
1532Z YL/BK 18 GA
REVERSE MOTION SENSOR SIG 2432 GN
HI IDLE(+) 15106 DK BL/OR 18 GA
CNG FUEL GAUGE CNG FUEL LVL GN 18 GA
ELECTRONIC GROUND 1206P WH 14 GA
ELECTRONIC POWER 1113GG PK/BK 14 GA
P2
PDU SIGNAL
ALLISON RETARDER INDICATOR (-) 18125A DK GN/WH 18 GA
ABS POWER 1163 PK/BK 12 GA
DASH RETARDER LIGHT (-) 1537 BN/WH 18 GA
HEATED DRAIN VALVE 1181 PK/BK 12 GA
BACK-UP LIGHTS 1322 LT BL 16 GA
HEATED FUEL FILTER 1168L PK/BK 12 GA
AMMETER (BAT) 1439B BK/WH 16 GA
AMMETER (ALT) 1440A BK 16 GA
AUX FUNCTION RANGE INHIBIT 1701A LT BL 18 GA
NEUTRAL, INTERLOCK (-) 18114F DK GN/WH 18 GA
ALLISON IGNITION 11146E PK/BK 16 GA
DASH ABS LIGHT (-) 1710 LT BL 18 GA
HI IDLE(+) 15106 DK BL/OR 18 GA
HI IDLE #2 1513C DK GN/YL 18 GA
REVERSE SIGNAL (-) 18113 DK GN/WH 18 GA
IGNITION DROPOUT 1168V PK/BK 16 GA
ABS WARNING LIGHT (-) 1744 LT BL 18 GA
NEUTRAL(START)(+) 18123 TN 18 GA
BRAKE SIGNAL (+) 1316AA RD 18 GA
1113GG PK/BK 14 GA
1206P WH 14 GA
1113GA BK 12 GA
1214J WH 12 GA
1528K 14 GA
1221AJ WH 14 GA
1152 BK 14 GA
1701B LT BL 18 GA
2305 OR/BN 14 GA
2309 BN 14 GA
1212KK WH 14 GA
1181E PK/BK 14 GA
DASH ELECTRONIC POWER
DASH ELECTRONIC GROUND
ALLISON ELECTRONIC POWER
ALLISON ELECTRONIC GROUND
HAYDEN FAN PWR
CHASSIS GRD
P1
PDU PWR
HAYDEN FAN PWR
P35
AUX FUNCTION RANGE INHIBIT
P37
TRANSMISSION INPUT/OUTPUT
(CONNECTS TO TRANSMISSION HARNESS)
M
FAN MOTOR
DRIVER'S HEATER
P4
HTD DRAIN VALVE
(RR BRAKE TANK)
P21
13
11
14
12
3
5
9
10



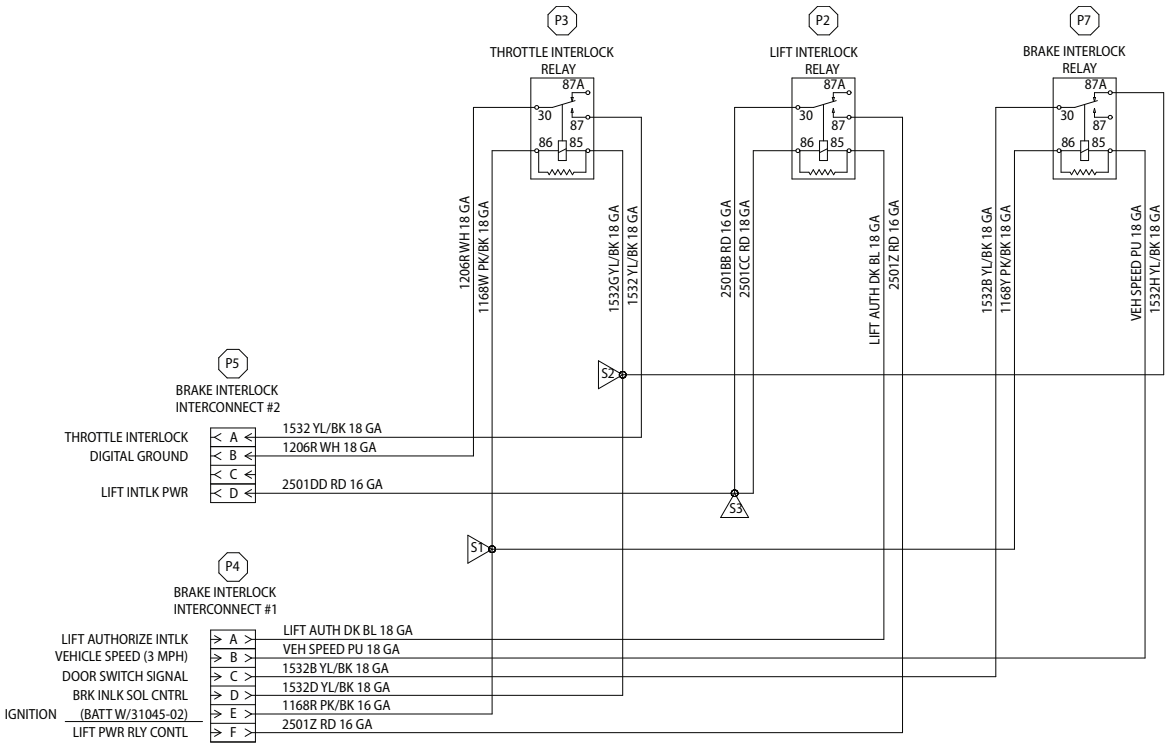
Frame, Cummins, ISL-G, RE

D0003545A



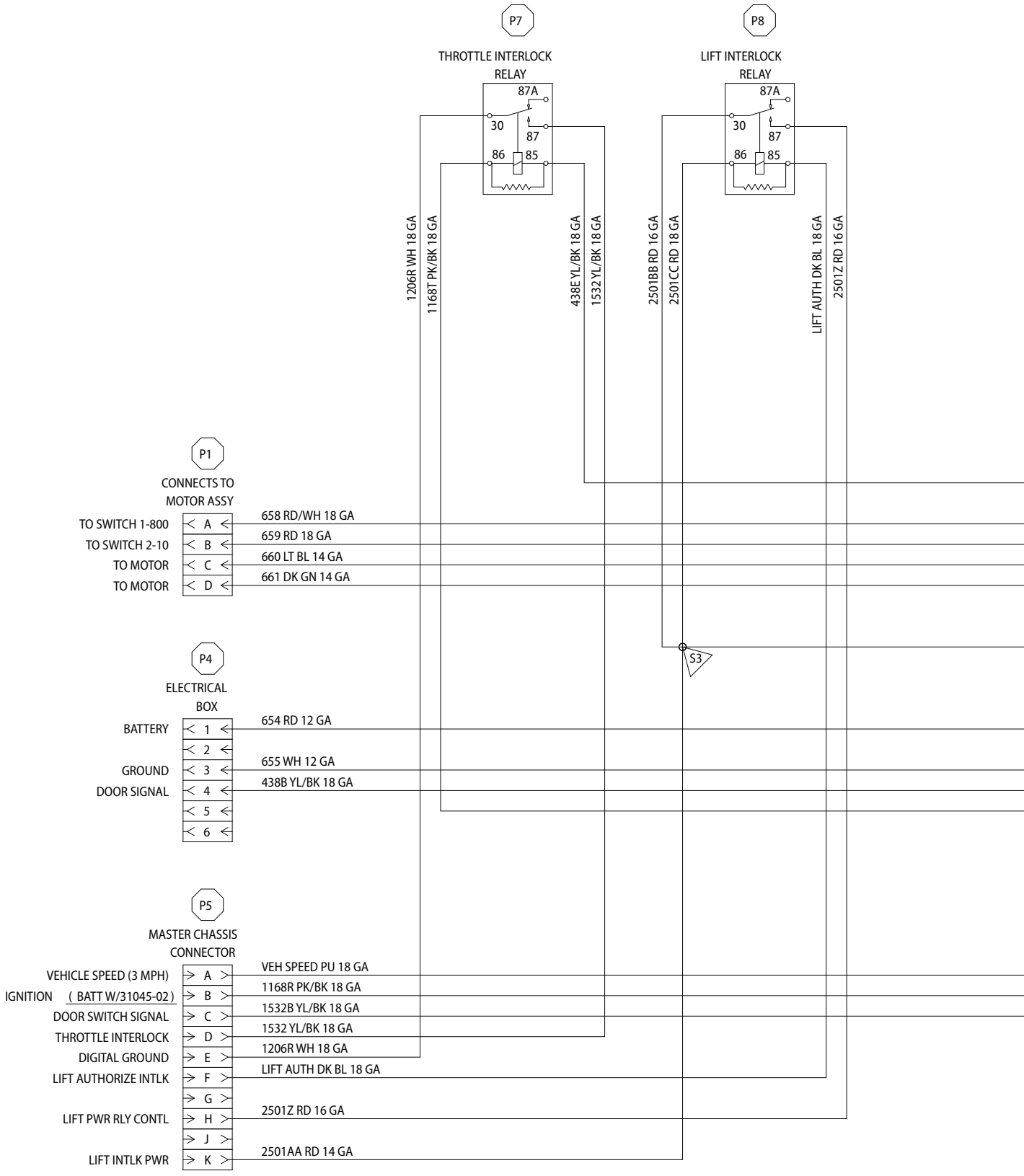
Brake/Lift, Interlock, FE & RE

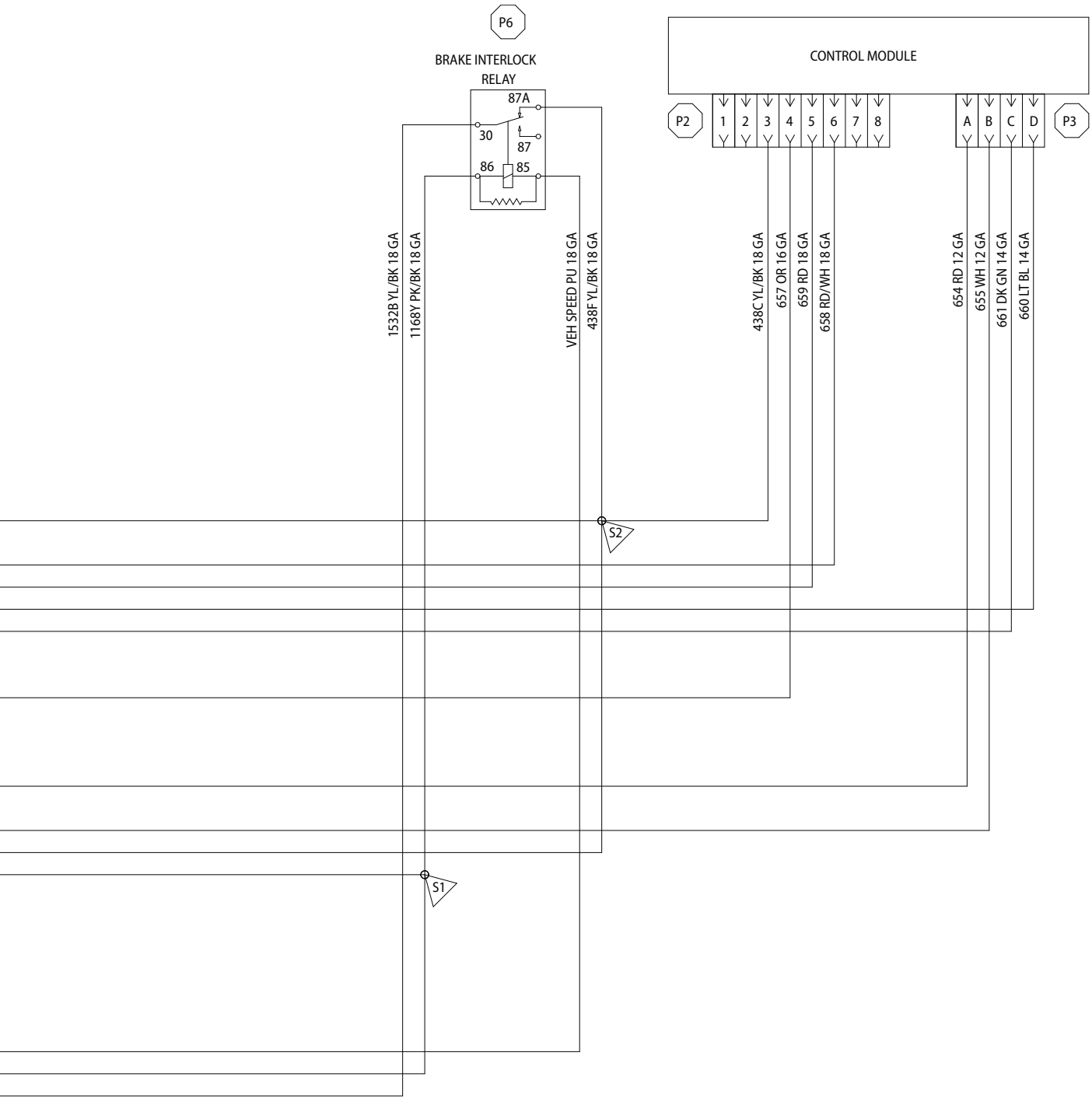
0115423A



Brake/Lift, Interlock, Air, FE

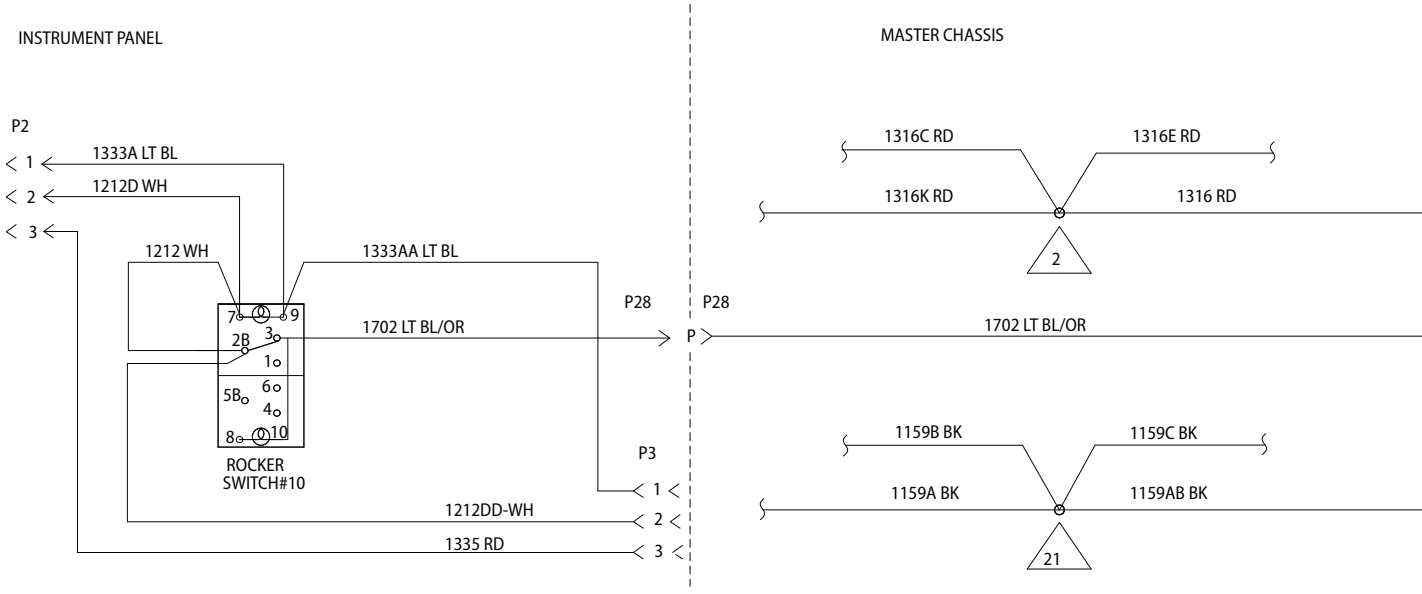
0115424A

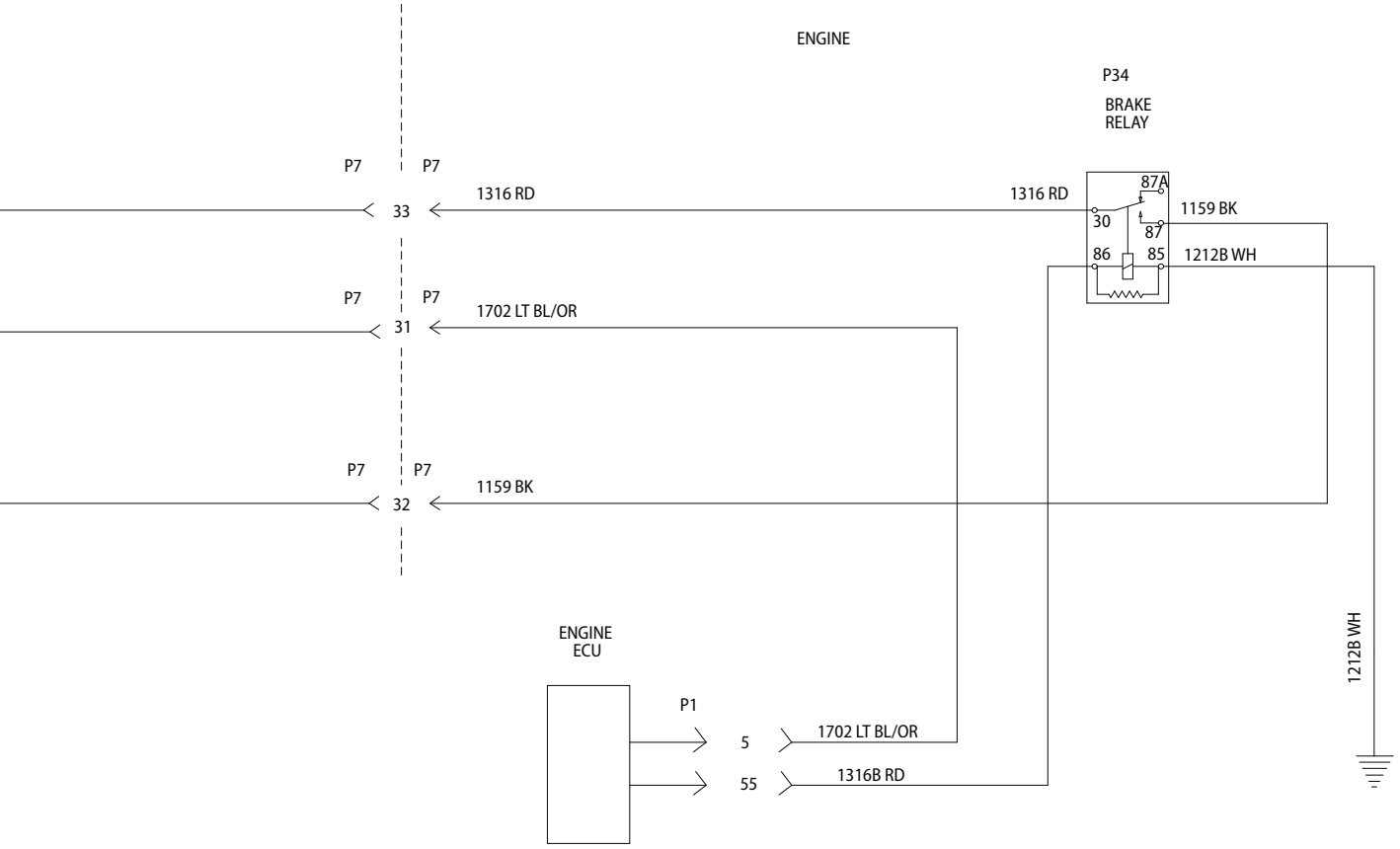

P7
THROTTLE INTERLOCK RELAY
87A
30
87
86
85
P8
LIFT INTERLOCK RELAY
87A
30
87
86
85
1206R WH 18 GA
1168T PK/BK 18 GA
438E YL/BK 18 GA
1532 YL/BK 18 GA
2501BB RD 16 GA
2501CC RD 18 GA
LIFT AUTH DK BL 18 GA
2501Z RD 16 GA
P1
CONNECTS TO MOTOR ASSY
TO SWITCH 1-800
TO SWITCH 2-10
TO MOTOR
TO MOTOR
A
B
C
D
658 RD/WH 18 GA
659 RD 18 GA
660 LT BL 14 GA
661 DK GN 14 GA
S3
P4
ELECTRICAL BOX
BATTERY
GROUND
DOOR SIGNAL
1
2
3
4
5
6
654 RD 12 GA
655 WH 12 GA
438B YL/BK 18 GA
P5
MASTER CHASSIS CONNECTOR
VEHICLE SPEED (3 MPH)
IGNITION (BATT W/31045-02)
DOOR SWITCH SIGNAL
THROTTLE INTERLOCK
DIGITAL GROUND
LIFT AUTHORIZE INTLK
LIFT PWR RLY CONTL
LIFT INTLK PWR
A
B
C
D
E
F
G
H
J
K
VEH SPEED PU 18 GA
1168R PK/BK 18 GA
1532B YL/BK 18 GA
1532 YL/BK 18 GA
1206R WH 18 GA
LIFT AUTH DK BL 18 GA
2501Z RD 16 GA
2501AA RD 14 GA



Brake/Lift, Interlock, Hyd, FE & RE

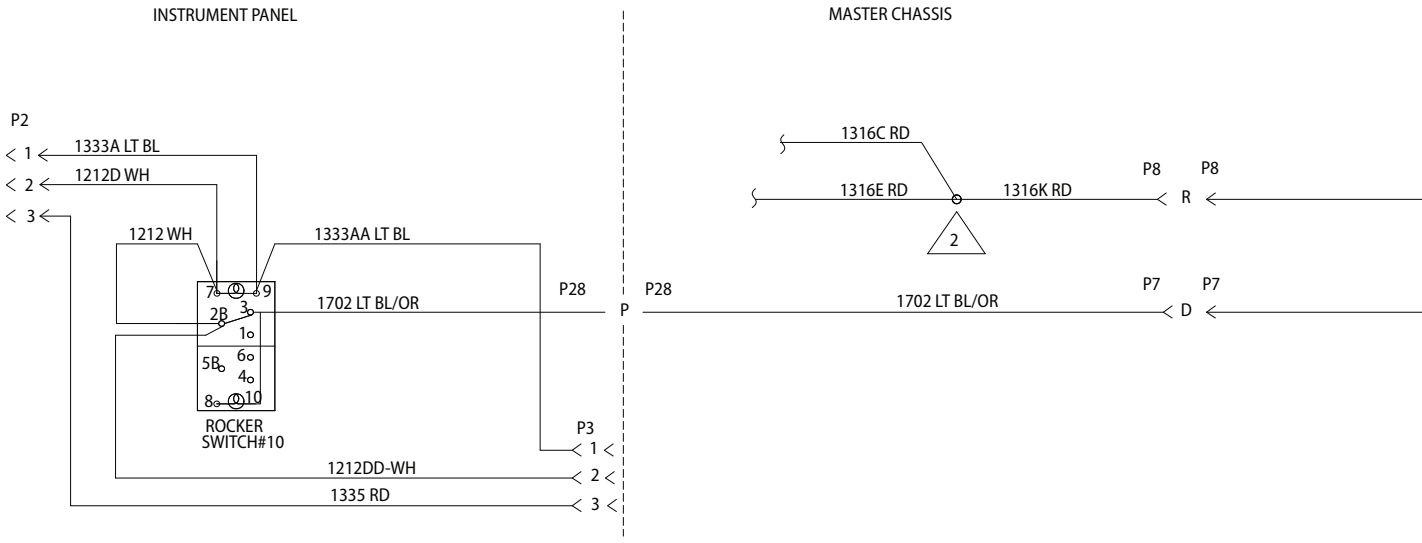
0114461A

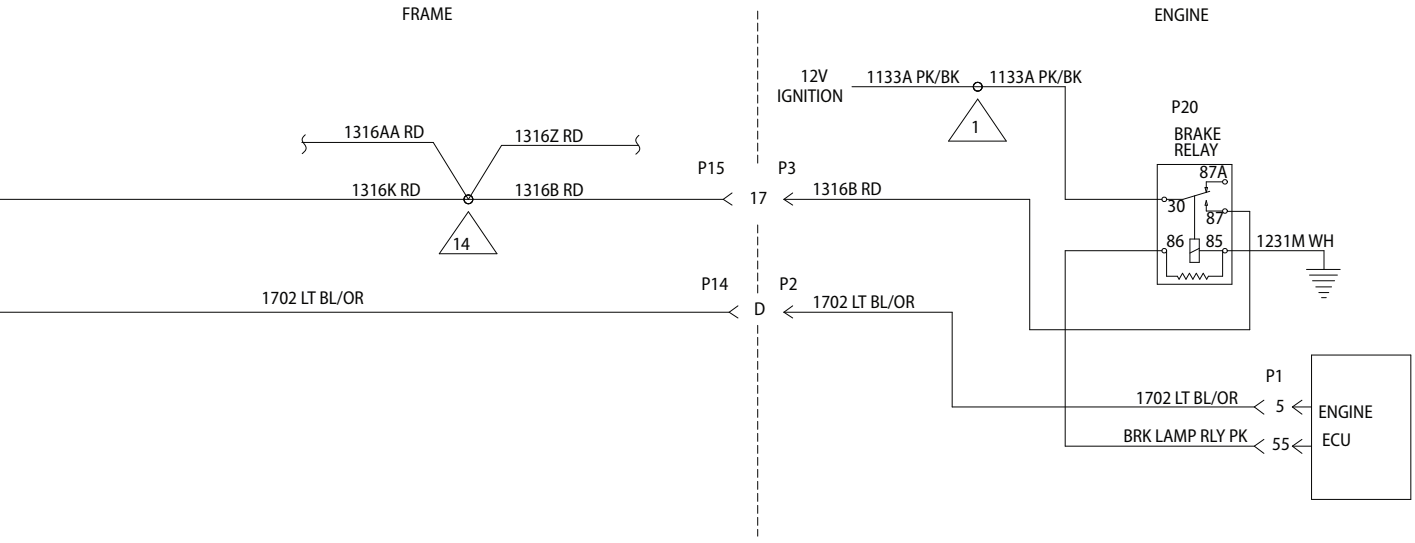

INSTRUMENT PANEL
MASTER CHASSIS
P2
1
2
3
1333A LT BL
1212D WH
1212 WH
1333AA LT BL
7
9
2B
3
1
5B
6
4
8
10
ROCKER
SWITCH#10
1702 LT BL/OR
P28
P
P28
1702 LT BL/OR
P3
1
2
3
1212DD-WH
1335 RD
1316C RD
1316E RD
1316K RD
1316 RD
2
1159B BK
1159C BK
1159A BK
1159AB BK
21



VGT Brake, ISB-07, FE

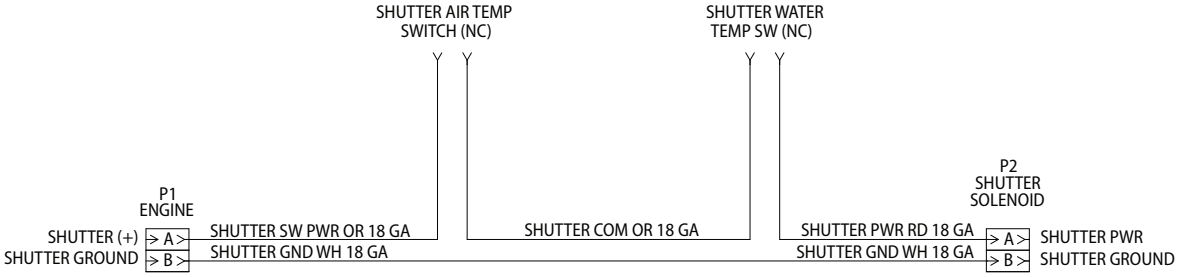
0106311


INSTRUMENT PANEL
MASTER CHASSIS
P2
1
2
3
1333A LT BL
1212D WH
1212 WH
1333AA LT BL
7
9
2B
3
1
5B
6
4
8
10
ROCKER
SWITCH#10
1702 LT BL/OR
P28
P
P3
1
2
3
1212DD-WH
1335 RD
1316C RD
1316E RD
1316K RD
2
P8
P8
R
P28
1702 LT BL/OR
P7
P7
D



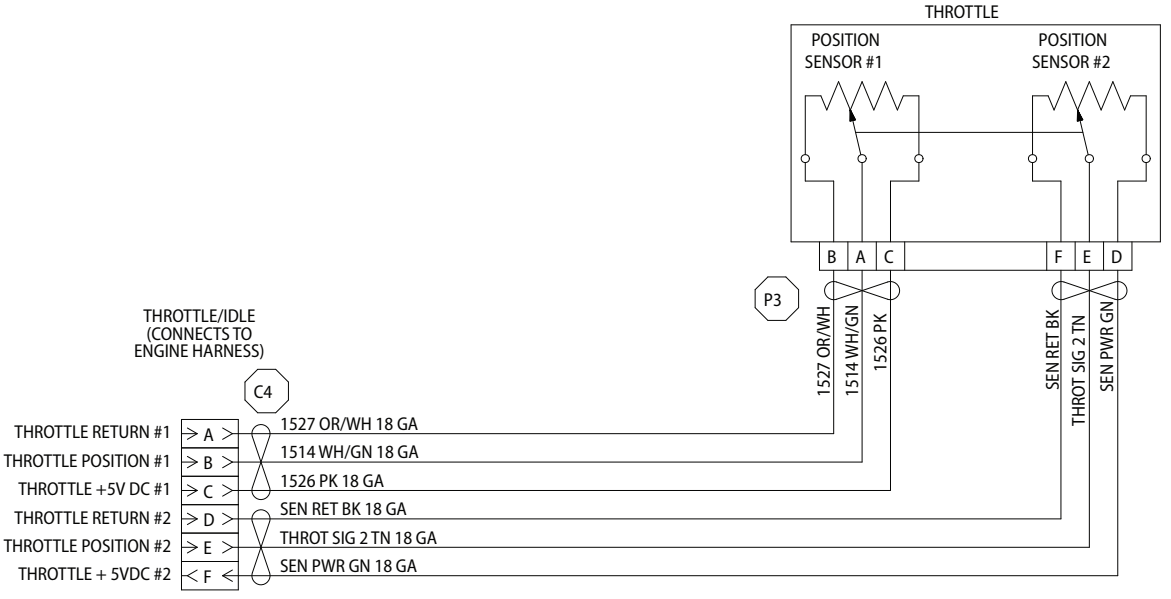
VGT Brake, ISB-07, RE

0112255



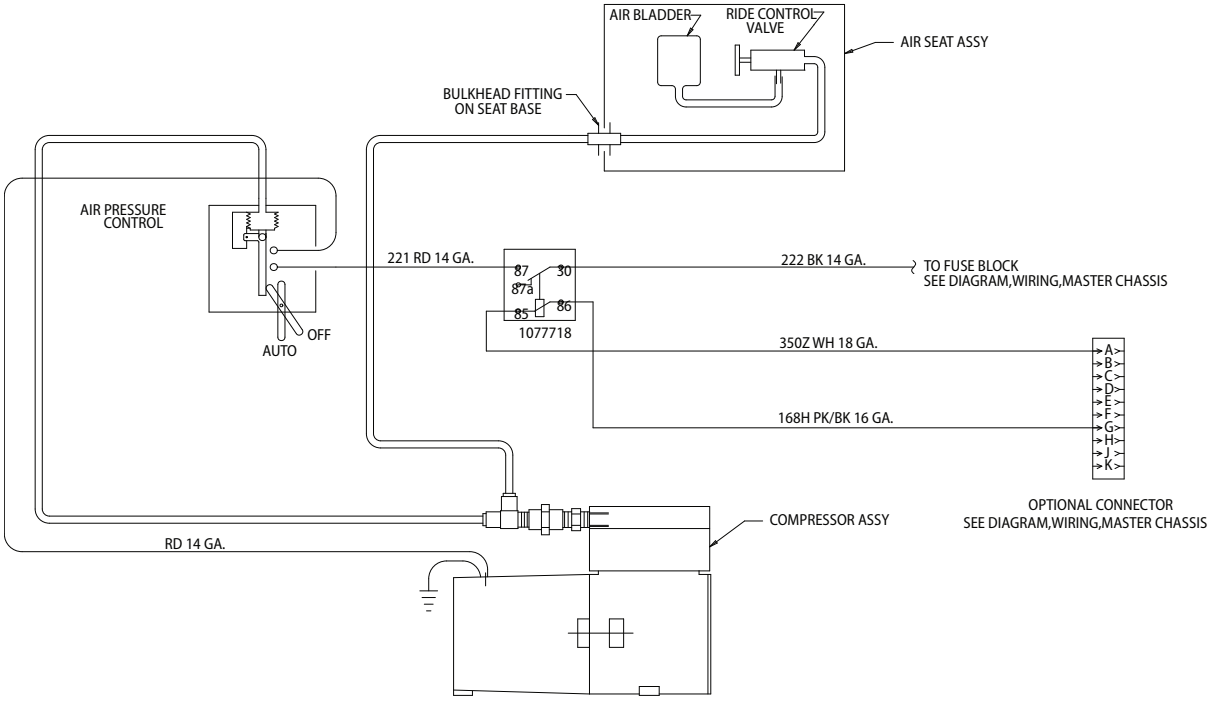
Shutters, FE

0117440



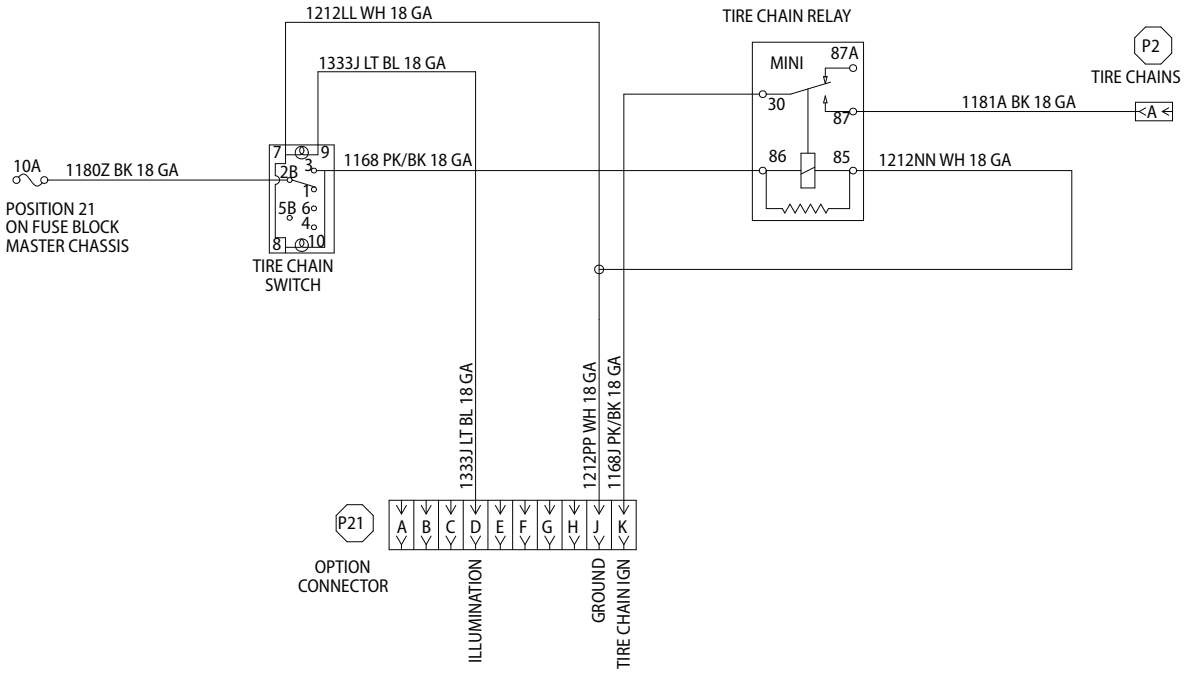
Throttle, ISB-07, FE

0104653



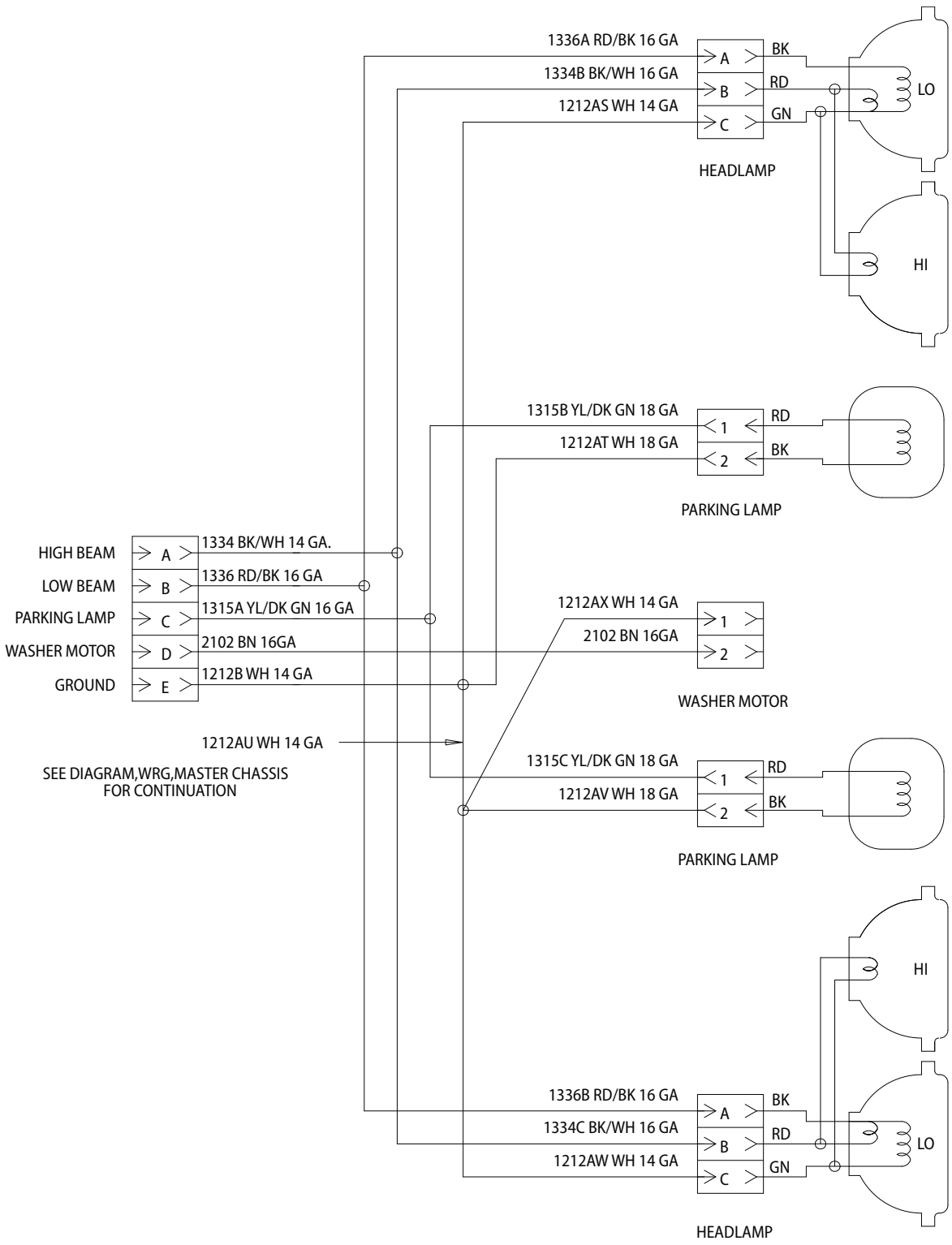
Compressor, Air Seat, FE & RE

1701887C



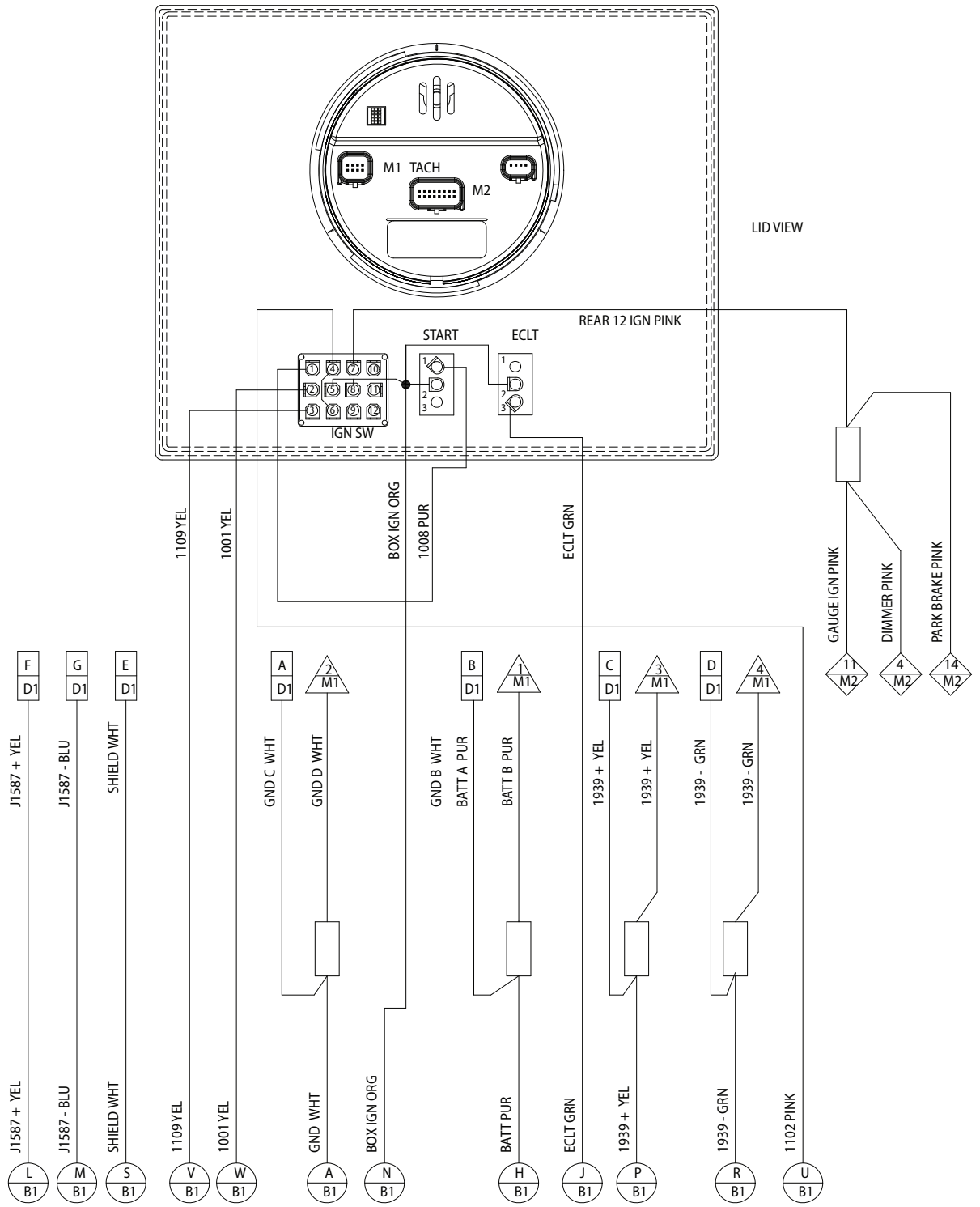
Tire Chains, FE & RE

0086714



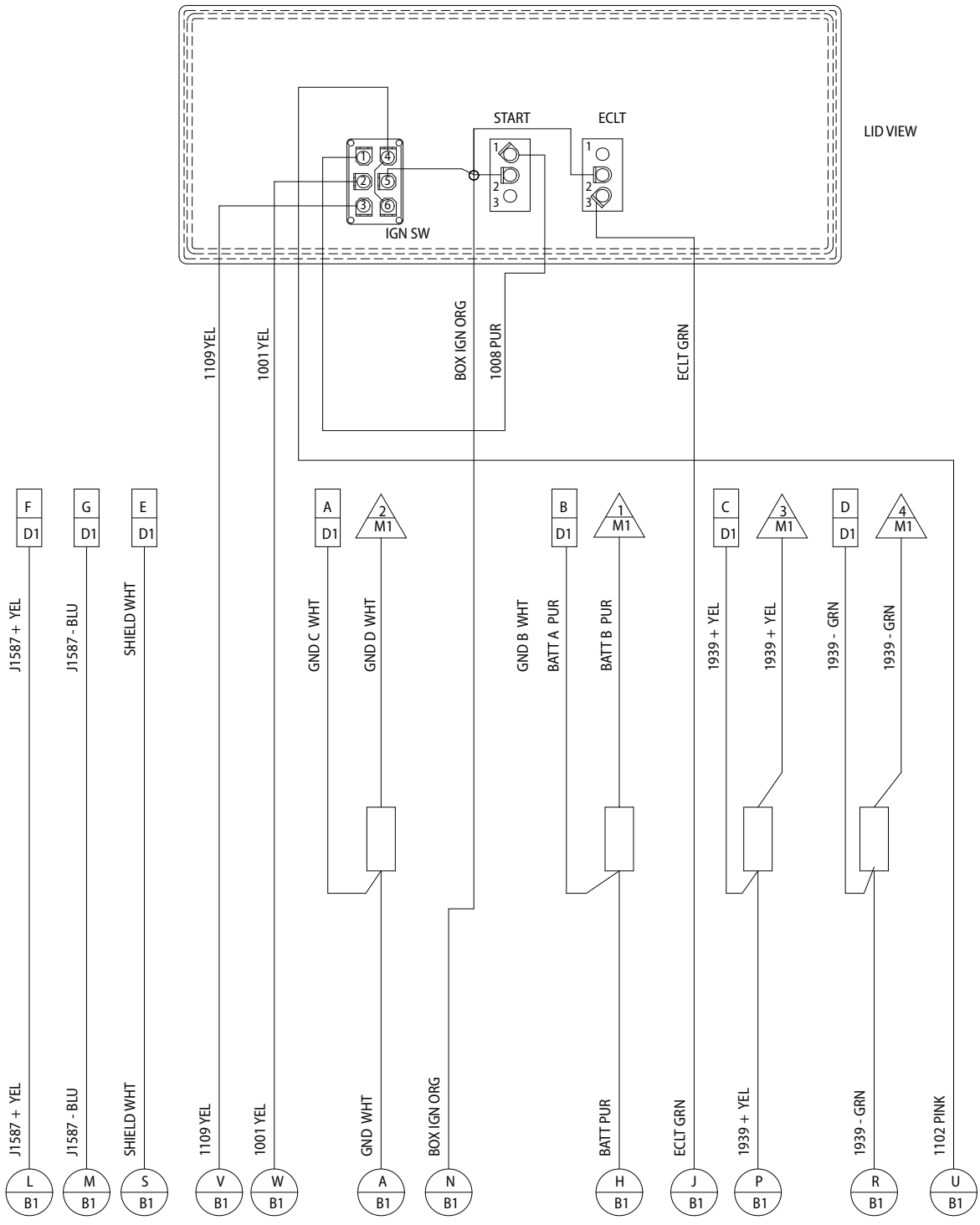
Headlamp & Washer Motor, FE & RE

0067740



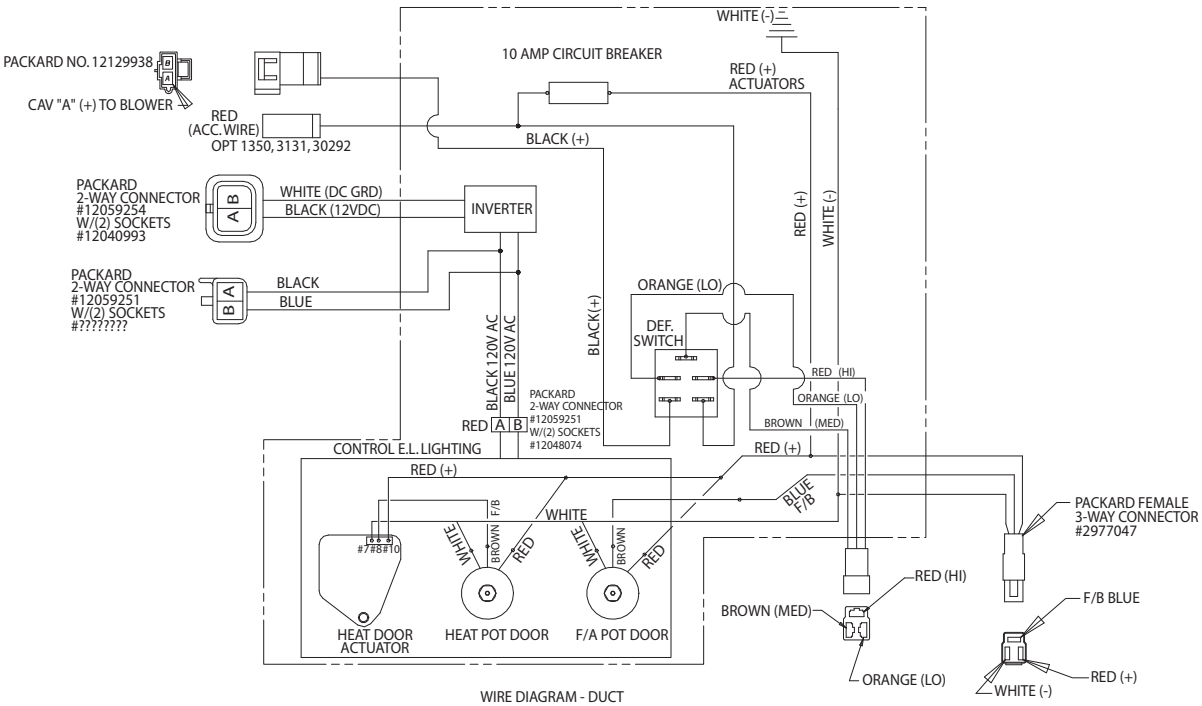
Rear Control Box, Actia, RE

0079080B

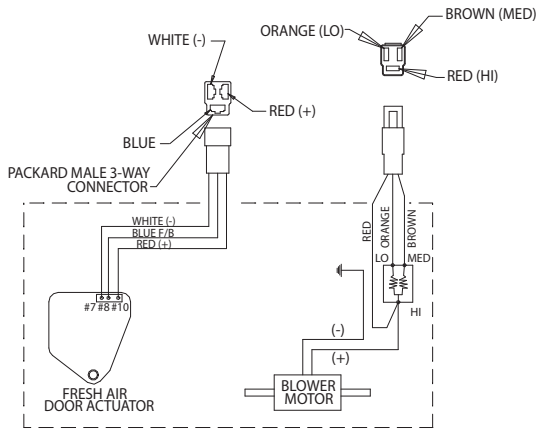


Rear Control Box, RE

0113028



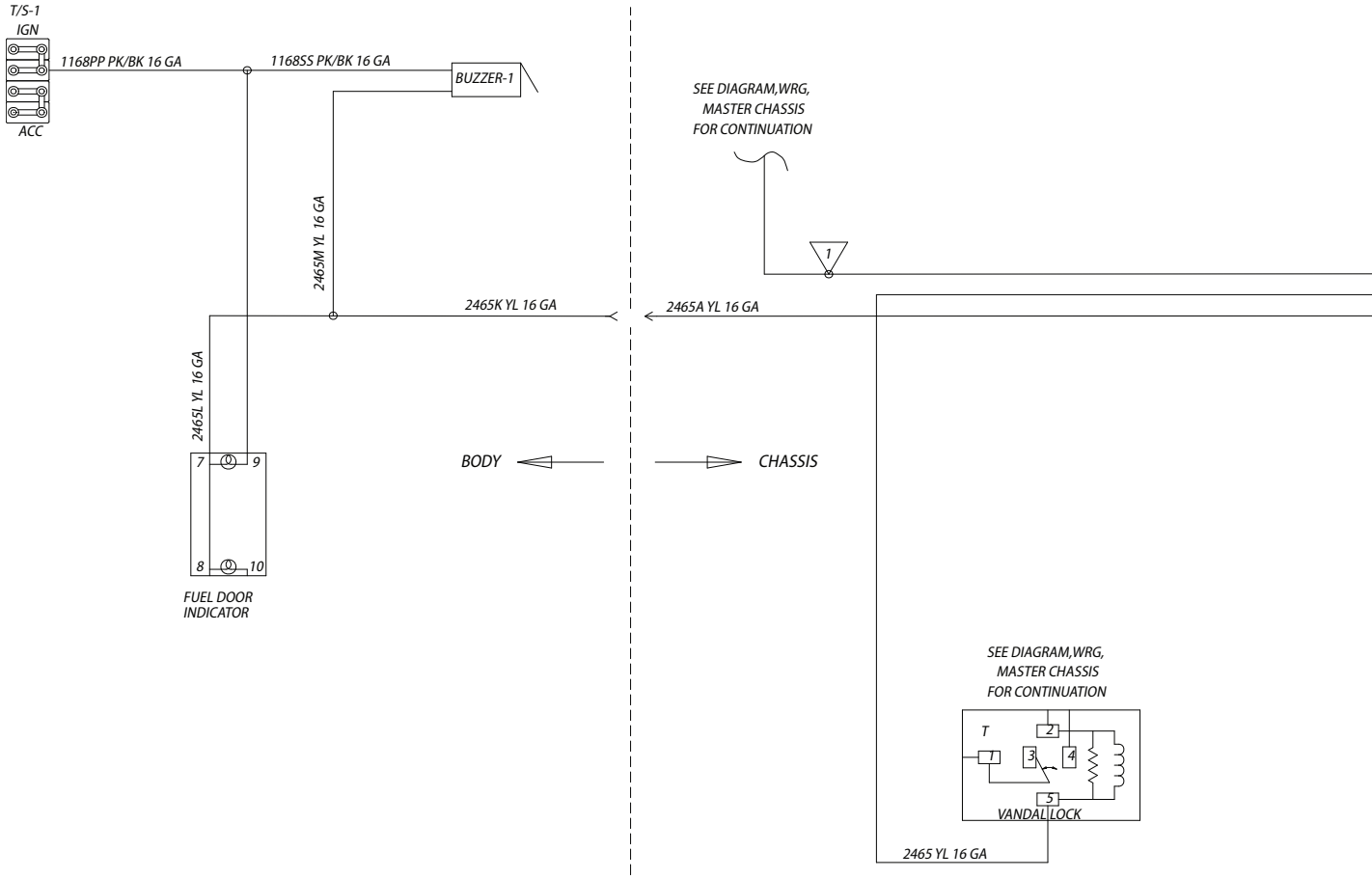
WIRE DIAGRAM - DUCT

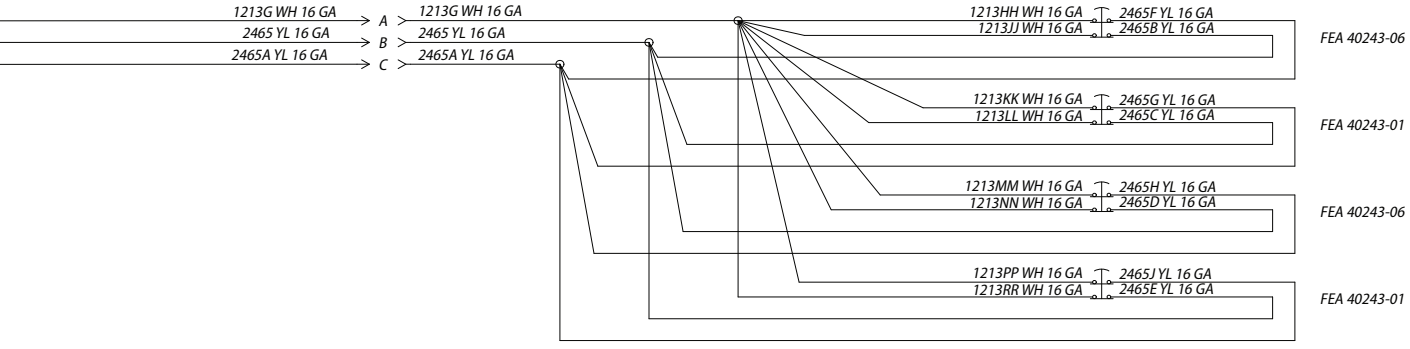


WIRE DIAGRAM HEATER ASSEMBLY

Heater & Defroster, Kysor

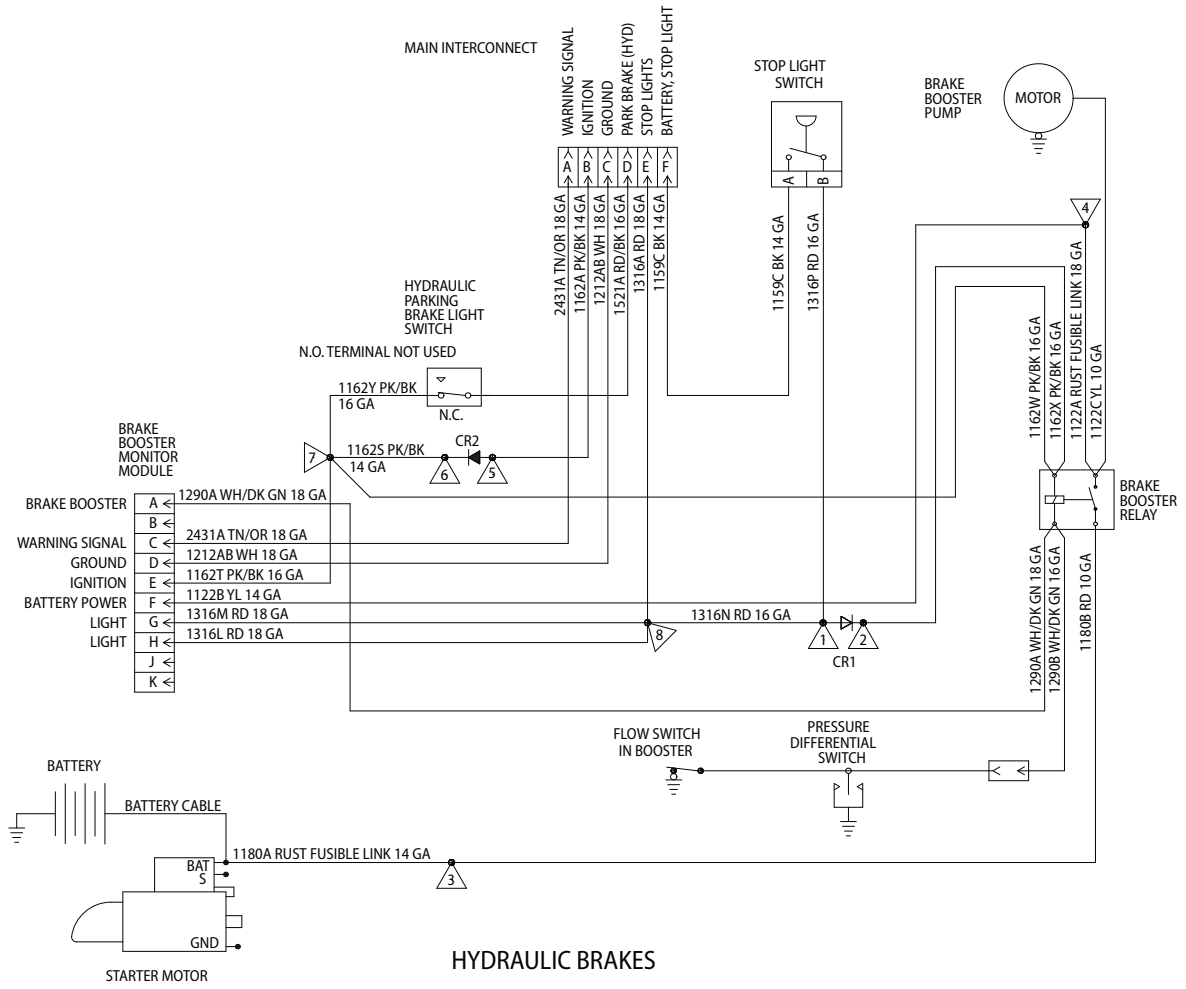
0026974


T/S-1
IGN
ACC
1168PP PK/BK 16 GA
1168SS PK/BK 16 GA
BUZZER-1
2465M YL 16 GA
2465K YL 16 GA
2465L YL 16 GA
7
9
8
10
FUEL DOOR
INDICATOR
BODY
CHASSIS
SEE DIAGRAM,WRG,
MASTER CHASSIS
FOR CONTINUATION
1
2465A YL 16 GA
SEE DIAGRAM,WRG,
MASTER CHASSIS
FOR CONTINUATION
T
2
1
3
4
5
VANDAL LOCK
2465 YL 16 GA



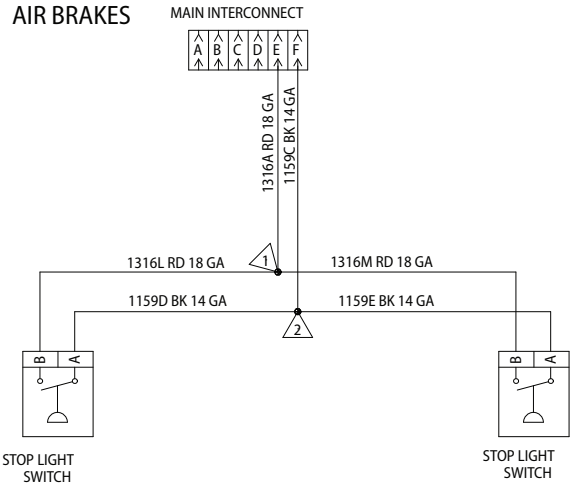
Fuel Door Latch Interlock, CNG

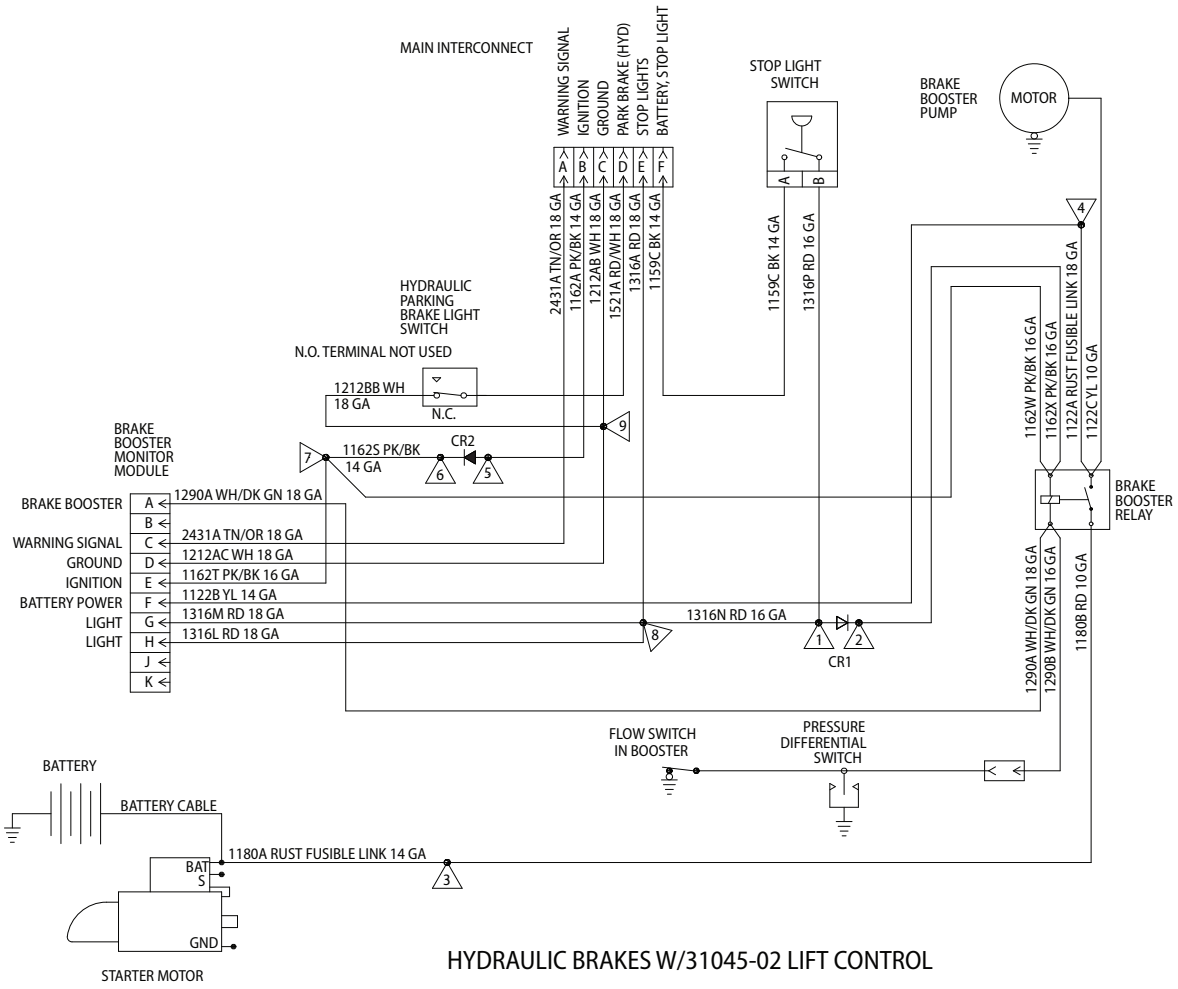
00086716



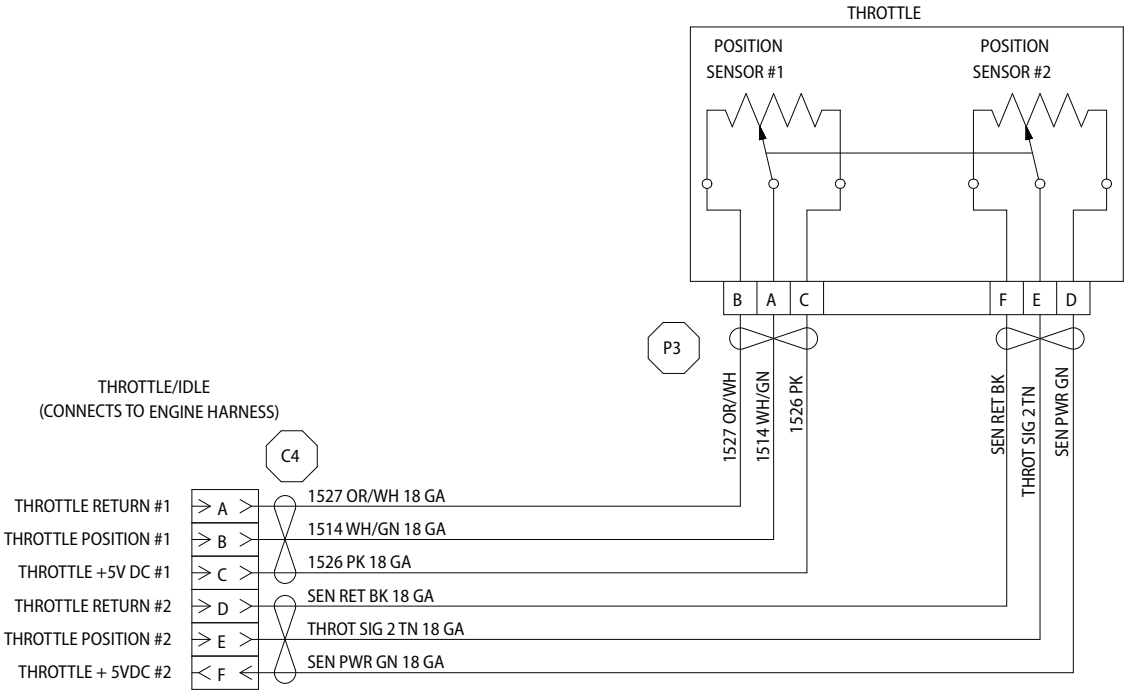
HYDRAULIC BRAKES

AIR BRAKES



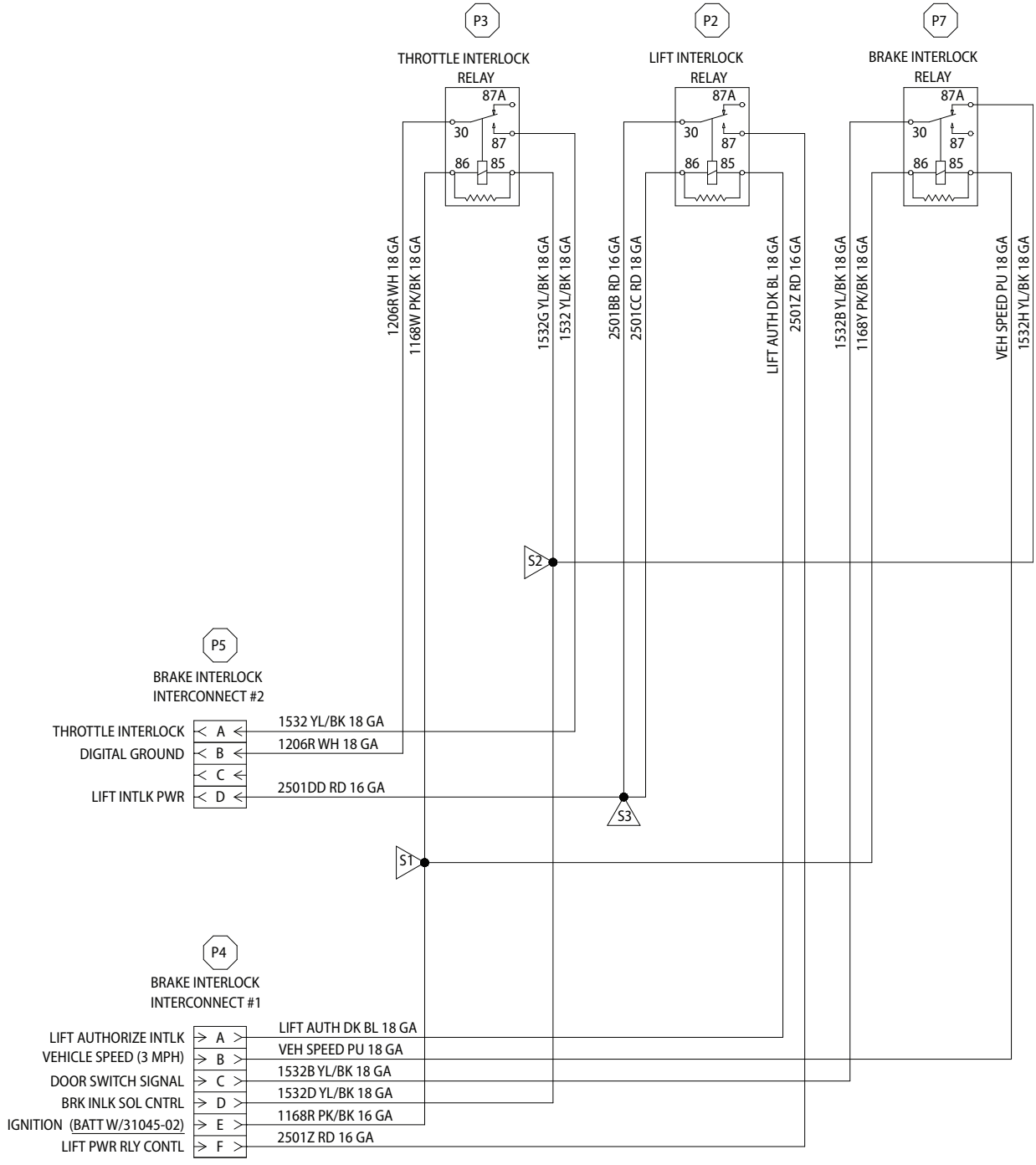


HYDRAULIC BRAKES W/31045-02 LIFT CONTROL



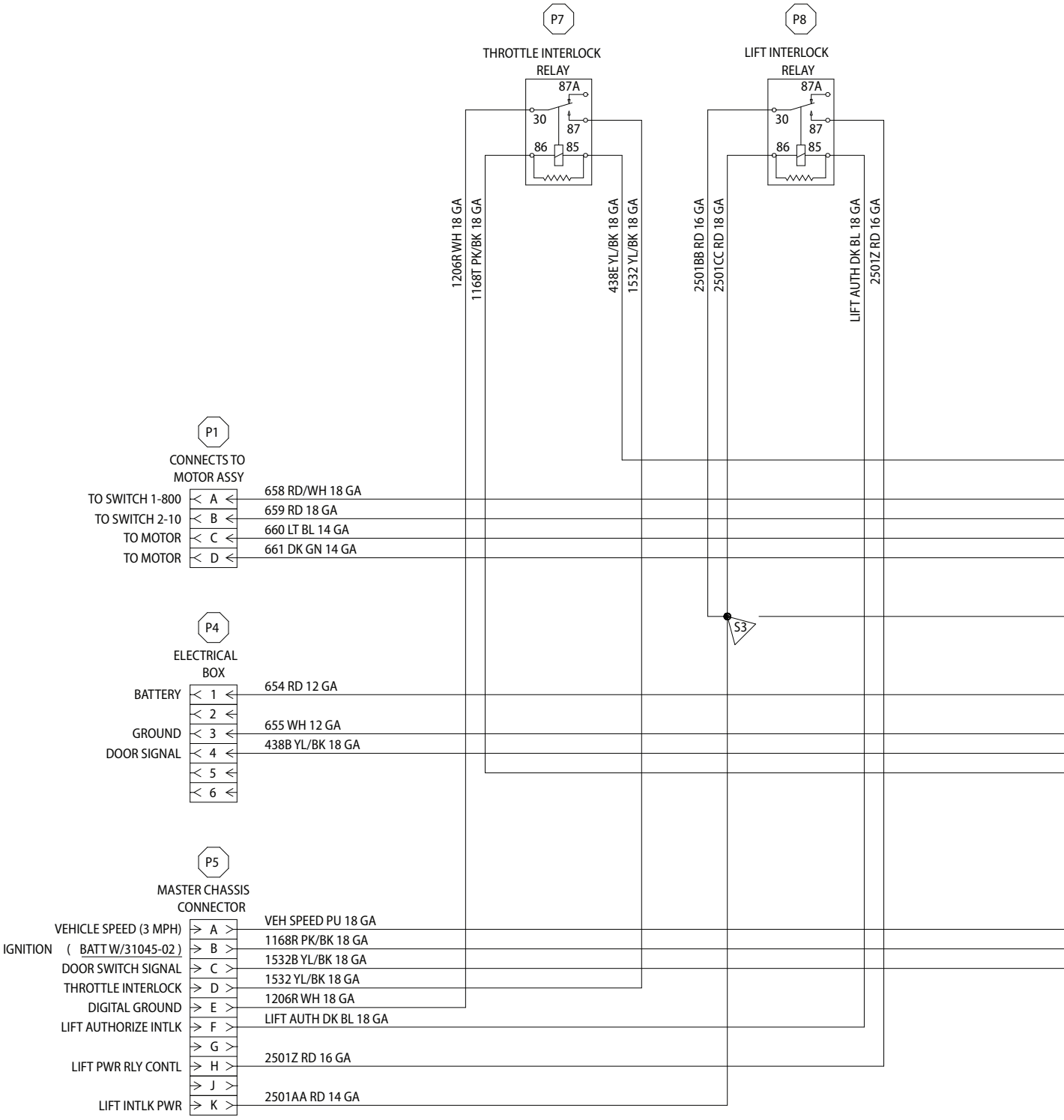
Throttle, ISB07

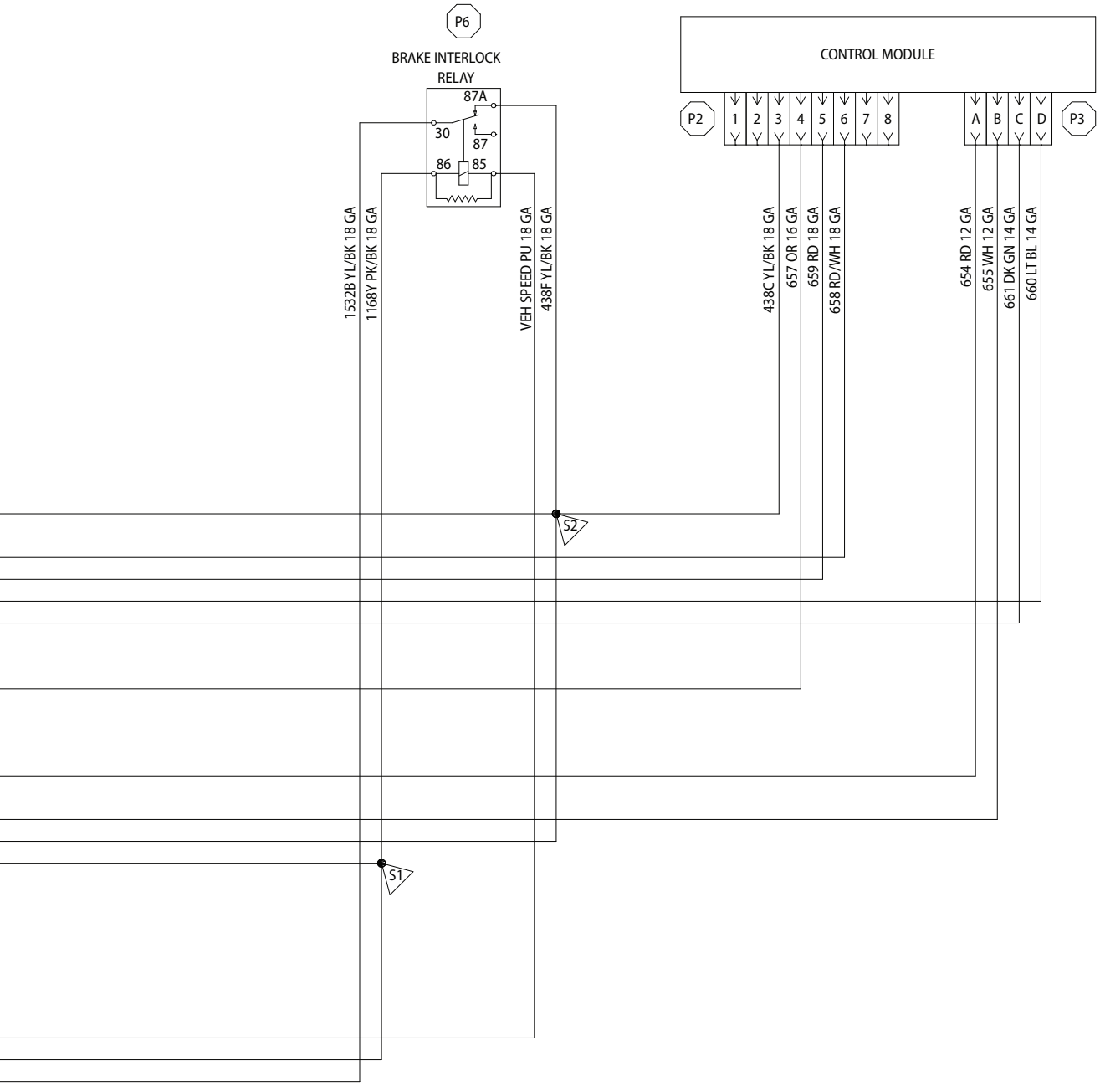
0104653



Air Brake Interlock

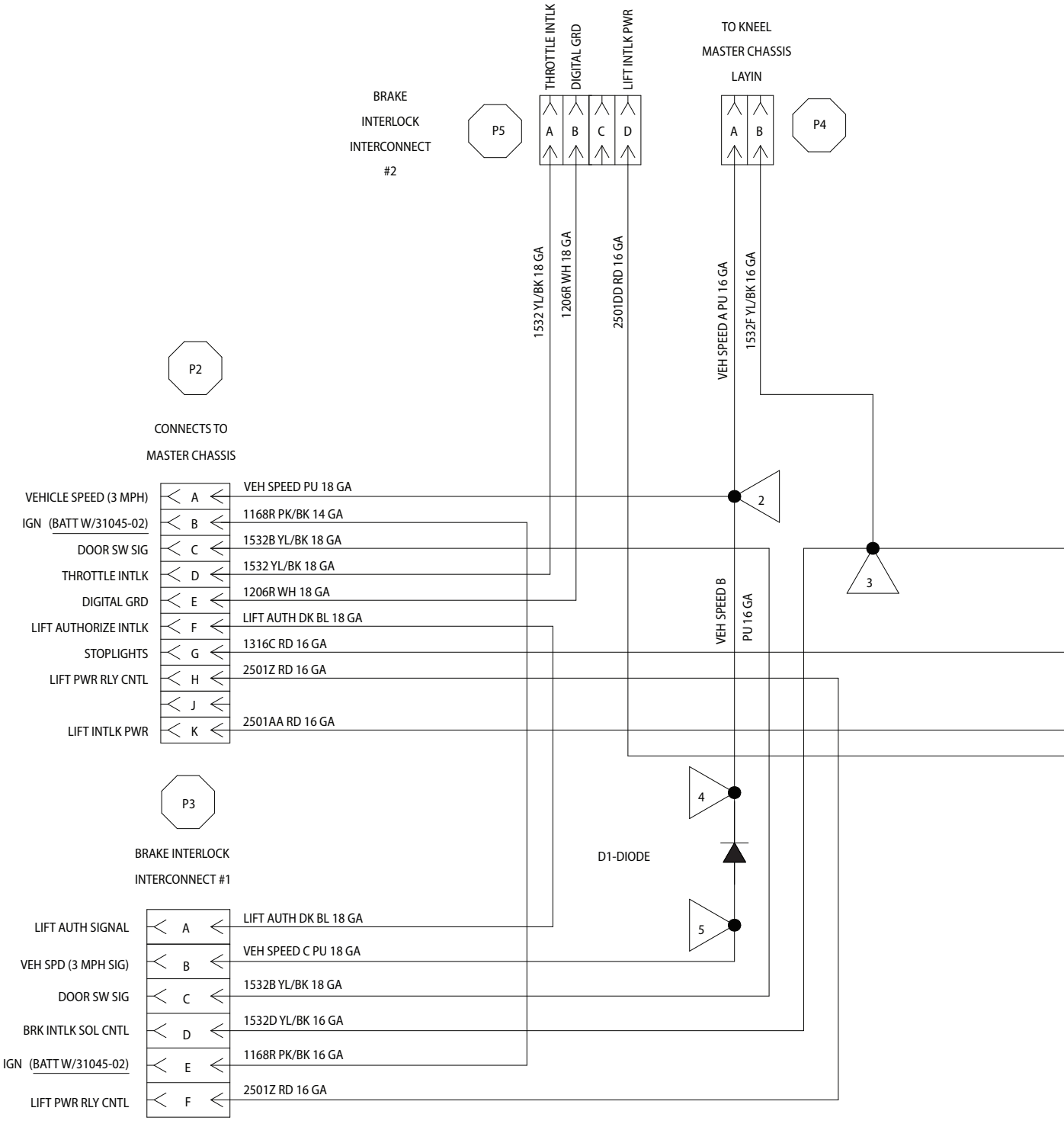
0115424A

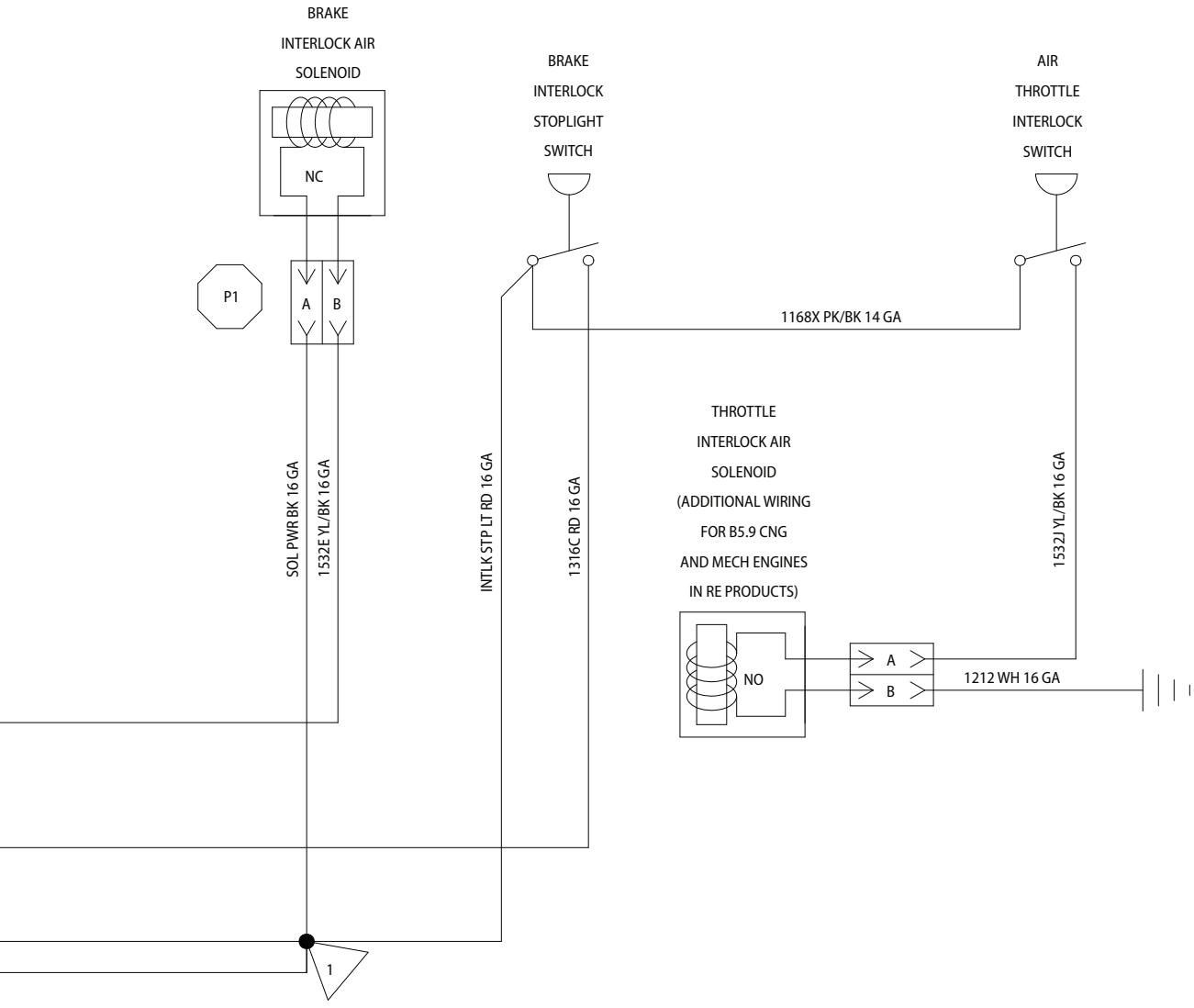

P7
THROTTLE INTERLOCK RELAY
87A
30
87
86
85
P8
LIFT INTERLOCK RELAY
87A
30
87
86
85
1206R WH 18 GA
1168T PK/BK 18 GA
438E YL/BK 18 GA
1532 YL/BK 18 GA
2501BB RD 16 GA
2501CC RD 18 GA
LIFT AUTH DK BL 18 GA
2501Z RD 16 GA
P1
CONNECTS TO MOTOR ASSY
TO SWITCH 1-800
A
658 RD/WH 18 GA
TO SWITCH 2-10
B
659 RD 18 GA
TO MOTOR
C
660 LT BL 14 GA
TO MOTOR
D
661 DK GN 14 GA
S3
P4
ELECTRICAL BOX
BATTERY
1
654 RD 12 GA
2
GROUND
3
655 WH 12 GA
DOOR SIGNAL
4
438B YL/BK 18 GA
5
6
P5
MASTER CHASSIS CONNECTOR
VEHICLE SPEED (3 MPH)
A
VEH SPEED PU 18 GA
IGNITION (BATT W/31045-02)
B
1168R PK/BK 18 GA
DOOR SWITCH SIGNAL
C
1532B YL/BK 18 GA
THROTTLE INTERLOCK
D
1532 YL/BK 18 GA
DIGITAL GROUND
E
1206R WH 18 GA
LIFT AUTHORIZE INTLK
F
LIFT AUTH DK BL 18 GA
G
LIFT PWR RLY CONTL
H
2501Z RD 16 GA
J
LIFT INTLK PWR
K
2501AA RD 14 GA



Hydraulic Brake Interlock

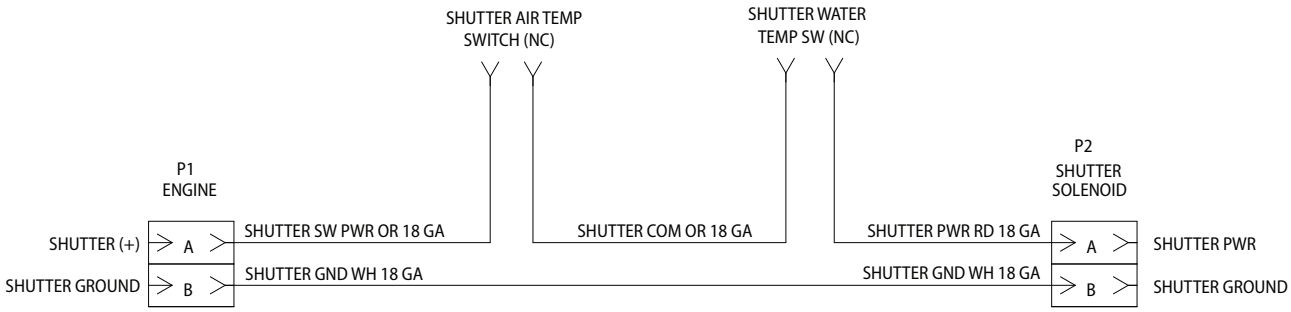
0114461A

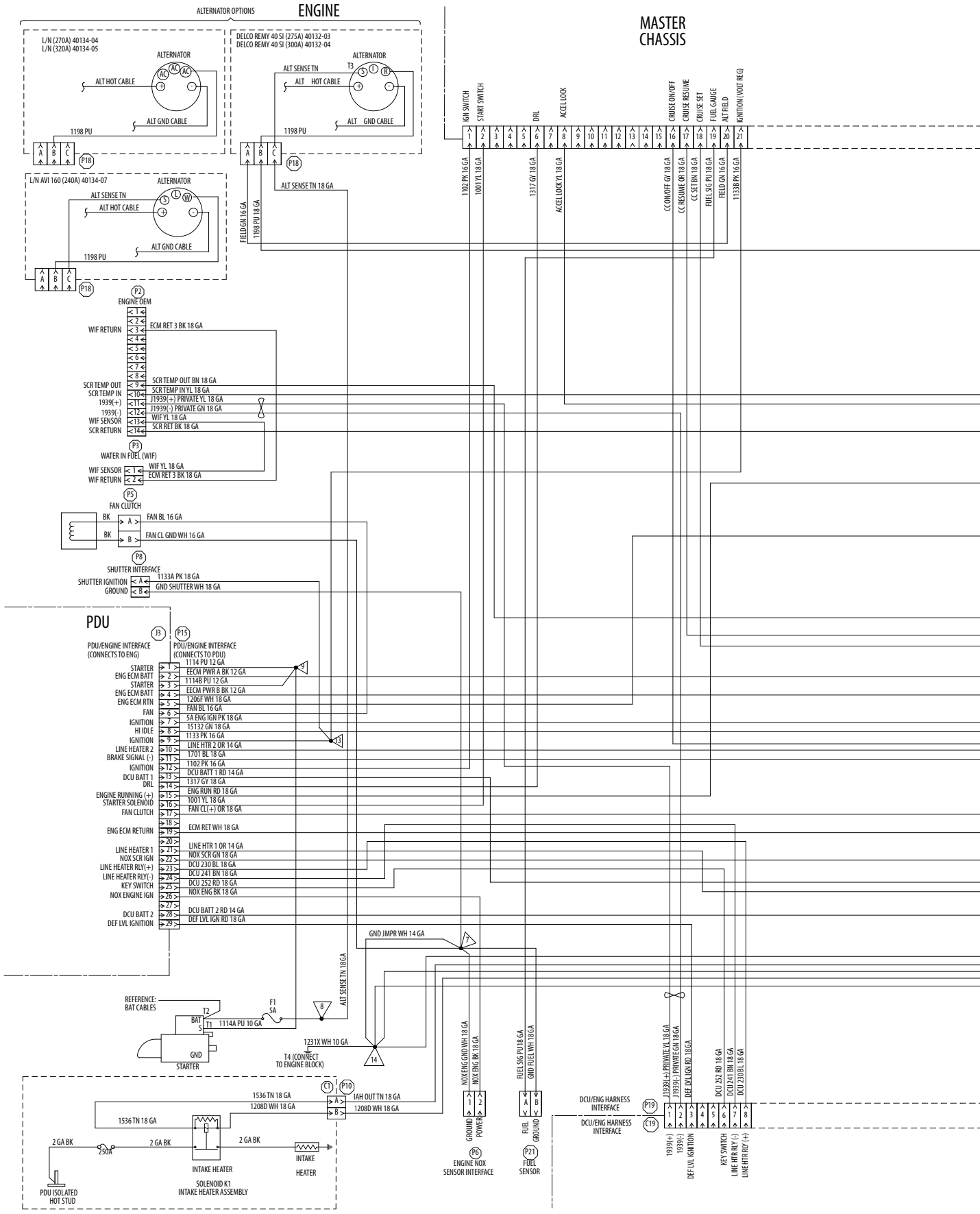

BRAKE
INTERLOCK
INTERCONNECT
#2
P5
THROTTLE INTLK
DIGITAL GRD
LIFT INTLK PWR
A
B
C
D
TO KNEEL
MASTER CHASSIS
LAYIN
P4
1532 YL/BK 18 GA
1206R WH 18 GA
2501DD RD 16 GA
VEH SPEED A PU 16 GA
1532F YL/BK 16 GA
P2
CONNECTS TO
MASTER CHASSIS
VEHICLE SPEED (3 MPH)
IGN (BATT W/31045-02)
DOOR SW SIG
THROTTLE INTLK
DIGITAL GRD
LIFT AUTHORIZE INTLK
STOPLIGHTS
LIFT PWR RLY CNTL
LIFT INTLK PWR
VEH SPEED PU 18 GA
1168R PK/BK 14 GA
1532B YL/BK 18 GA
1532 YL/BK 18 GA
1206R WH 18 GA
LIFT AUTH DK BL 18 GA
1316C RD 16 GA
2501Z RD 16 GA
2501AA RD 16 GA
VEH SPEED B
PU 16 GA
2
3
4
5
D1-DIODE
P3
BRAKE INTERLOCK
INTERCONNECT #1
LIFT AUTH SIGNAL
VEH SPD (3 MPH SIG)
DOOR SW SIG
BRK INTLK SOL CNTL
IGN (BATT W/31045-02)
LIFT PWR RLY CNTL
LIFT AUTH DK BL 18 GA
VEH SPEED C PU 18 GA
1532B YL/BK 18 GA
1532D YL/BK 16 GA
1168R PK/BK 16 GA
2501Z RD 16 GA

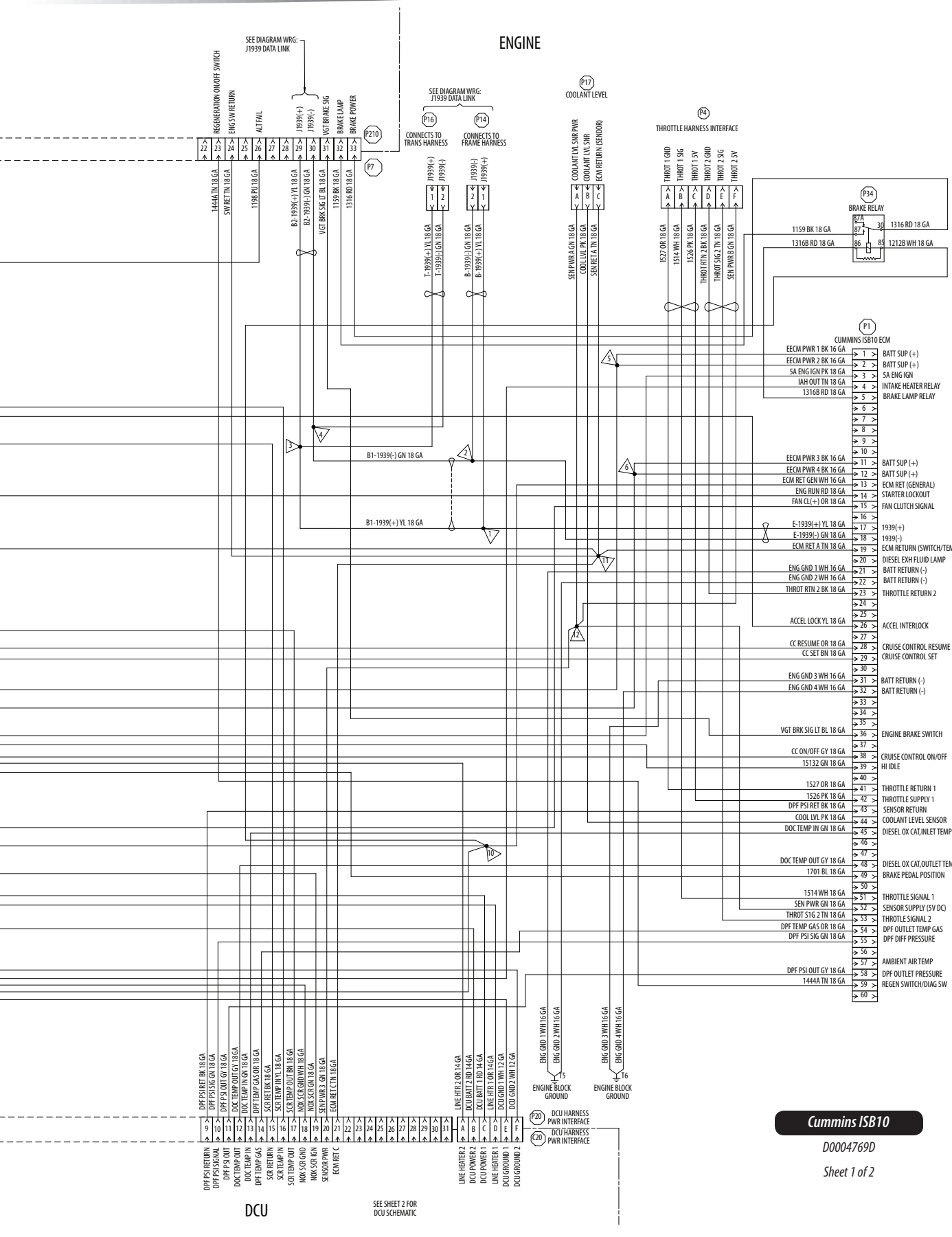


Brake Interlock

0115423A


SHUTTER AIR TEMP
SWITCH (NC)
SHUTTER WATER
TEMP SW (NC)
P1
ENGINE
P2
SHUTTER
SOLENOID
SHUTTER (+)
A
SHUTTER SW PWR OR 18 GA
SHUTTER COM OR 18 GA
SHUTTER PWR RD 18 GA
A
SHUTTER PWR
SHUTTER GROUND
B
SHUTTER GND WH 18 GA
SHUTTER GND WH 18 GA
B
SHUTTER GROUND


ENGINE
ALTERNATOR OPTIONS
L/N (270A) 40134-04
L/N (320A) 40134-05
ALTERNATOR
ALT HOT CABLE
ALT GND CABLE
1198 PU
P18
DELCO REMY 40 SI (275A) 40132-03
DELCO REMY 40 SI (300A) 40132-04
ALT SENSE TN
ALT SENSE TN 18 GA
L/N AVI 160 (240A) 40134-07
FIELD GN 16 GA
1198 PU 18 GA
MASTER CHASSIS
IGN SWITCH
START SWITCH
DRL
ACCEL LOCK
CRUISE ON/OFF
CRUISE RESUME
CRUISE SET
FUEL GAUGE
ALT FIELD
IGNITION (VOUT REG)
1102 PK 16 GA
1001 YL 18 GA
1317 GY 18 GA
ACCEL LOCK YL 18 GA
CC ON/OFF GY 18 GA
CC RESUME OR 18 GA
CC SET BN 18 GA
FUEL SIG PU 18 GA
FIELD GN 16 GA
1133B PK 16 GA
P2
ENGINE OEM
WIF RETURN
ECM RET 3 BK 18 GA
SCR TEMP OUT
SCR TEMP IN
1939(+)
1939(-)
WIF SENSOR
SCR RETURN
SCR TEMP OUT BN 18 GA
SCR TEMP IN YL 18 GA
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
WIF YL 18 GA
SCR RET BK 18 GA
P3
WATER IN FUEL (WIF)
WIF YL 18 GA
ECM RET 3 BK 18 GA
P5
FAN CLUTCH
BK
FAN BL 16 GA
FAN CL GND WH 16 GA
P8
SHUTTER INTERFACE
SHUTTER IGNITION
GROUND
1133A PK 18 GA
GND SHUTTER WH 18 GA
PDU
J3
P15
PDU/ENGINE INTERFACE (CONNECTS TO ENG)
PDU/ENGINE INTERFACE (CONNECTS TO PDU)
1114 PU 12 GA
STARTER
ENG ECM BATT
ENG ECM RTN
FAN
IGNITION
HI IDLE
LINE HEATER 2
BRAKE SIGNAL (-)
DCU BATT 1
DRL
ENGINE RUNNING (+)
STARTER SOLENOID
FAN CLUTCH
ENG ECM RETURN
LINE HEATER 1
NOX SCR IGN
LINE HEATER RLY(+)
LINE HEATER RLY(-)
KEY SWITCH
NOX ENGINE IGN
DCU BATT 2
DEF LVL IGNITION
EECM PWR A BK 12 GA
1114B PU 12 GA
EECM PWR B BK 12 GA
1206F WH 18 GA
FAN BL 16 GA
5A ENG IGN PK 18 GA
15132 GN 18 GA
1133 PK 16 GA
LINE HTR 2 OR 14 GA
1701 BL 18 GA
1102 PK 16 GA
DCU BATT 1 RD 14 GA
1317 GY 18 GA
ENG RUN RD 18 GA
1001 YL 18 GA
FAN CL(+) OR 18 GA
ECM RET WH 18 GA
LINE HTR 1 OR 14 GA
NOX SCR GN 18 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA
DCU 252 RD 18 GA
NOX ENG BK 18 GA
DCU BATT 2 RD 14 GA
DEF LVL IGN RD 18 GA
GND JMPR WH 14 GA
ALT SENSE TN 18GA
REFERENCE: BAT CABLES
T2
T1
1114A PU 10 GA
F1
5A
GND
STARTER
1231X WH 10 GA
T4 (CONNECT TO ENGINE BLOCK)
C1
P10
1536 TN 18 GA
1208D WH 18 GA
IAH OUT TN 18 GA
1208D WH 18 GA
1536 TN 18 GA
2 GA BK
250A
2 GA BK
2 GA BK
INTAKE HEATER
INTAKE HEATER
SOLENOID K1
INTAKE HEATER ASSEMBLY
PDU ISOLATED HOT STUD
NOX ENG GND WH 18 GA
NOX ENG BK 18 GA
GROUND
POWER
P6
ENGINE NOX SENSOR INTERFACE
FUEL SIG PU 18 GA
GND FUEL WH 18 GA
FUEL
GROUND
P21
FUEL SENSOR
DCU/ENG HARNESS INTERFACE
P19
C19
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
DEF LVL IGN RD 18GA
DCU 252 RD 18 GA
DCU 241 BN 18 GA
DCU 230BL 18 GA
1939(+)
1939(-)
DEF LVL IGNITION
KEY SWITCH
LINE HTR RLY (-)
LINE HTR RLY (+)



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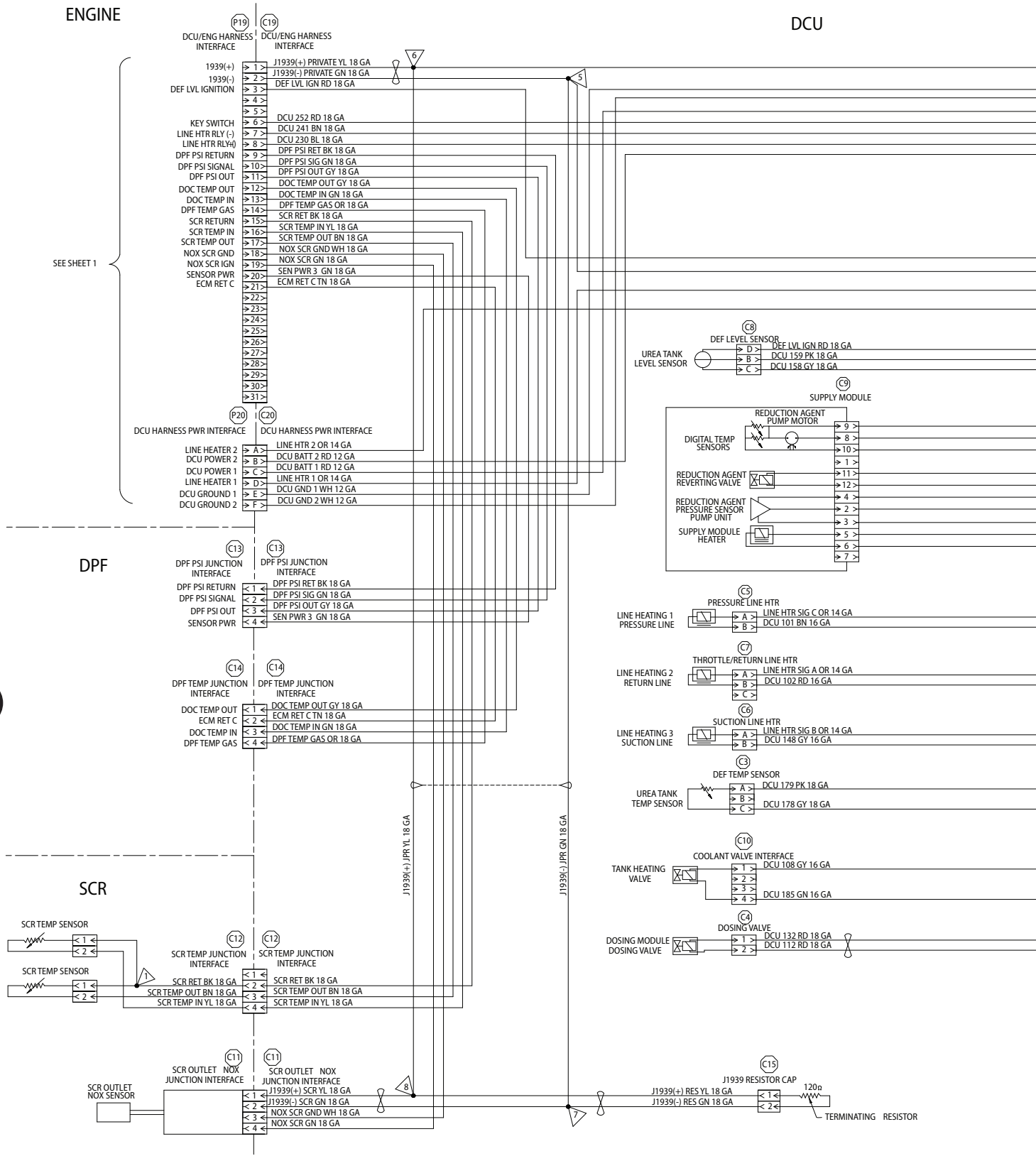
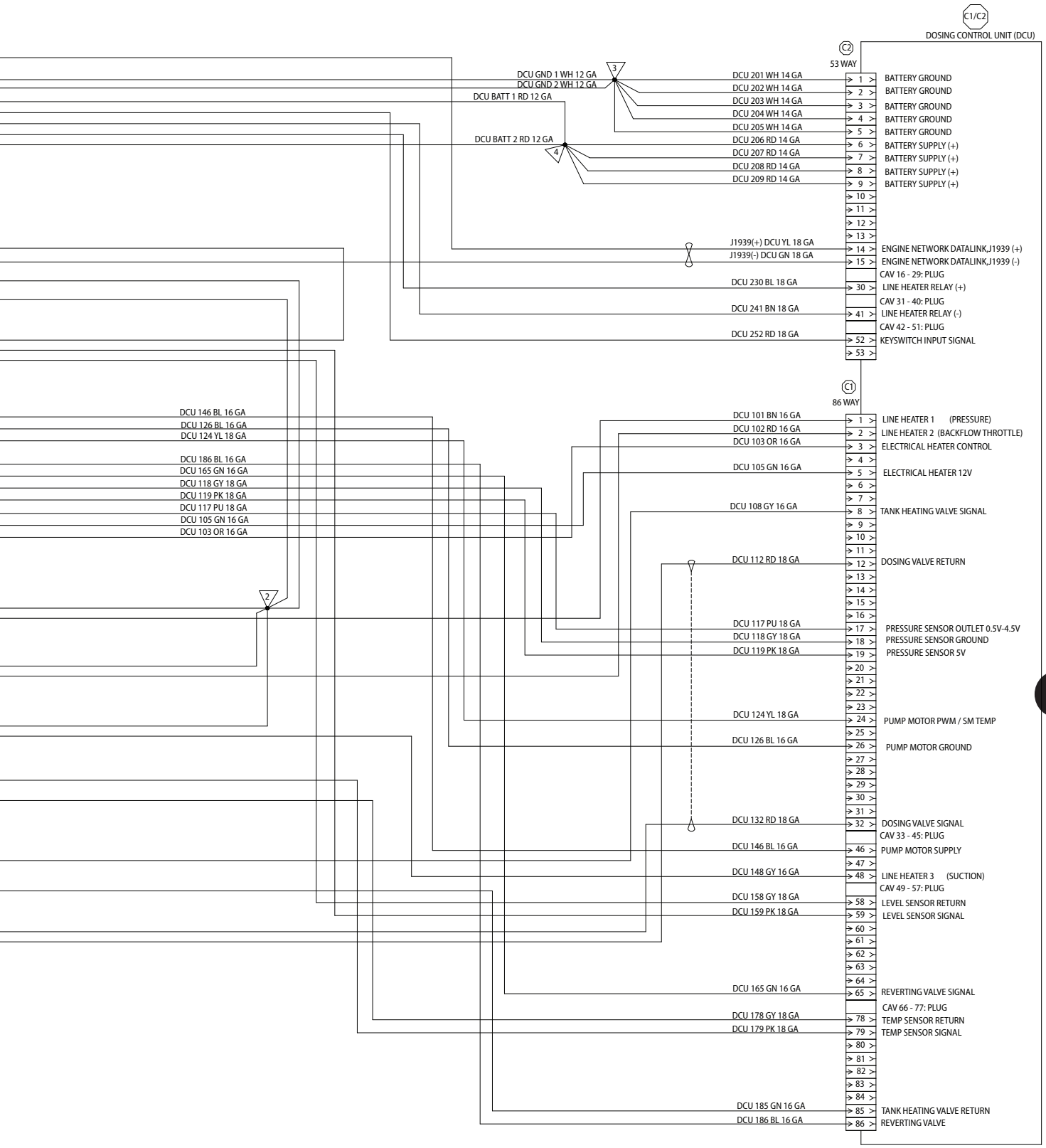
Sheet 1 of 2


ENGINE
DCU
DPF
SCR
P19
C19
DCU/ENG HARNESS INTERFACE
DCU/ENG HARNESS INTERFACE
1939(+)
1939(-)
DEF LVL IGNITION
KEY SWITCH
LINE HTR RLY (-)
LINE HTR RLY(+)
DPF PSI RETURN
DPF PSI SIGNAL
DPF PSI OUT
DOC TEMP OUT
DOC TEMP IN
DPF TEMP GAS
SCR RETURN
SCR TEMP IN
SCR TEMP OUT
NOX SCR GND
NOX SCR IGN
SENSOR PWR
ECM RET C
SEE SHEET 1
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
DEF LVL IGN RD 18 GA
DCU 252 RD 18 GA
DCU 241 BN 18 GA
DCU 230 BL 18 GA
DPF PSI RET BK 18 GA
DPF PSI SIG GN 18 GA
DPF PSI OUT GY 18 GA
DOC TEMP OUT GY 18 GA
DOC TEMP IN GN 18 GA
DPF TEMP GAS OR 18 GA
SCR RET BK 18 GA
SCR TEMP IN YL 18 GA
SCR TEMP OUT BN 18 GA
NOX SCR GND WH 18 GA
NOX SCR GN 18 GA
SEN PWR 3 GN 18 GA
ECM RET C TN 18 GA
P20
C20
DCU HARNESS PWR INTERFACE
DCU HARNESS PWR INTERFACE
LINE HEATER 2
DCU POWER 2
DCU POWER 1
LINE HEATER 1
DCU GROUND 1
DCU GROUND 2
LINE HTR 2 OR 14 GA
DCU BATT 2 RD 12 GA
DCU BATT 1 RD 12 GA
LINE HTR 1 OR 14 GA
DCU GND 1 WH 12 GA
DCU GND 2 WH 12 GA
C13
C13
DPF PSI JUNCTION INTERFACE
DPF PSI JUNCTION INTERFACE
DPF PSI RETURN
DPF PSI SIGNAL
DPF PSI OUT
SENSOR PWR
C14
C14
DPF TEMP JUNCTION INTERFACE
DPF TEMP JUNCTION INTERFACE
DOC TEMP OUT
ECM RET C
DOC TEMP IN
DPF TEMP GAS
SCR TEMP SENSOR
SCR TEMP SENSOR
C12
C12
SCR TEMP JUNCTION INTERFACE
SCR TEMP JUNCTION INTERFACE
SCR RET BK 18 GA
SCR TEMP OUT BN 18 GA
SCR TEMP IN YL 18 GA
C11
C11
SCR OUTLET NOX JUNCTION INTERFACE
SCR OUTLET NOX JUNCTION INTERFACE
SCR OUTLET NOX SENSOR
J1939(+) SCR YL 18 GA
J1939(-) SCR GN 18 GA
NOX SCR GND WH 18 GA
NOX SCR GN 18 GA
J1939(+) JPR YL 18 GA
J1939(-) JPR GN 18 GA
C8
DEF LEVEL SENSOR
UREA TANK LEVEL SENSOR
DEF LVL IGN RD 18 GA
DCU 159 PK 18 GA
DCU 158 GY 18 GA
C9
SUPPLY MODULE
REDUCTION AGENT PUMP MOTOR
DIGITAL TEMP SENSORS
REDUCTION AGENT REVERTING VALVE
REDUCTION AGENT PRESSURE SENSOR PUMP UNIT
SUPPLY MODULE HEATER
C5
PRESSURE LINE HTR
LINE HEATING 1 PRESSURE LINE
LINE HTR SIG C OR 14 GA
DCU 101 BN 16 GA
C7
THROTTLE/RETURN LINE HTR
LINE HEATING 2 RETURN LINE
LINE HTR SIG A OR 14 GA
DCU 102 RD 16 GA
C6
SUCTION LINE HTR
LINE HEATING 3 SUCTION LINE
LINE HTR SIG B OR 14 GA
DCU 148 GY 16 GA
C3
DEF TEMP SENSOR
UREA TANK TEMP SENSOR
DCU 179 PK 18 GA
DCU 178 GY 18 GA
C10
COOLANT VALVE INTERFACE
TANK HEATING VALVE
DCU 108 GY 16 GA
DCU 185 GN 16 GA
C4
DOSING VALVE
DOSING MODULE DOSING VALVE
DCU 132 RD 18 GA
DCU 112 RD 18 GA
C15
J1939 RESISTOR CAP
J1939(+) RES YL 18 GA
J1939(-) RES GN 18 GA
120Ω
TERMINATING RESISTOR



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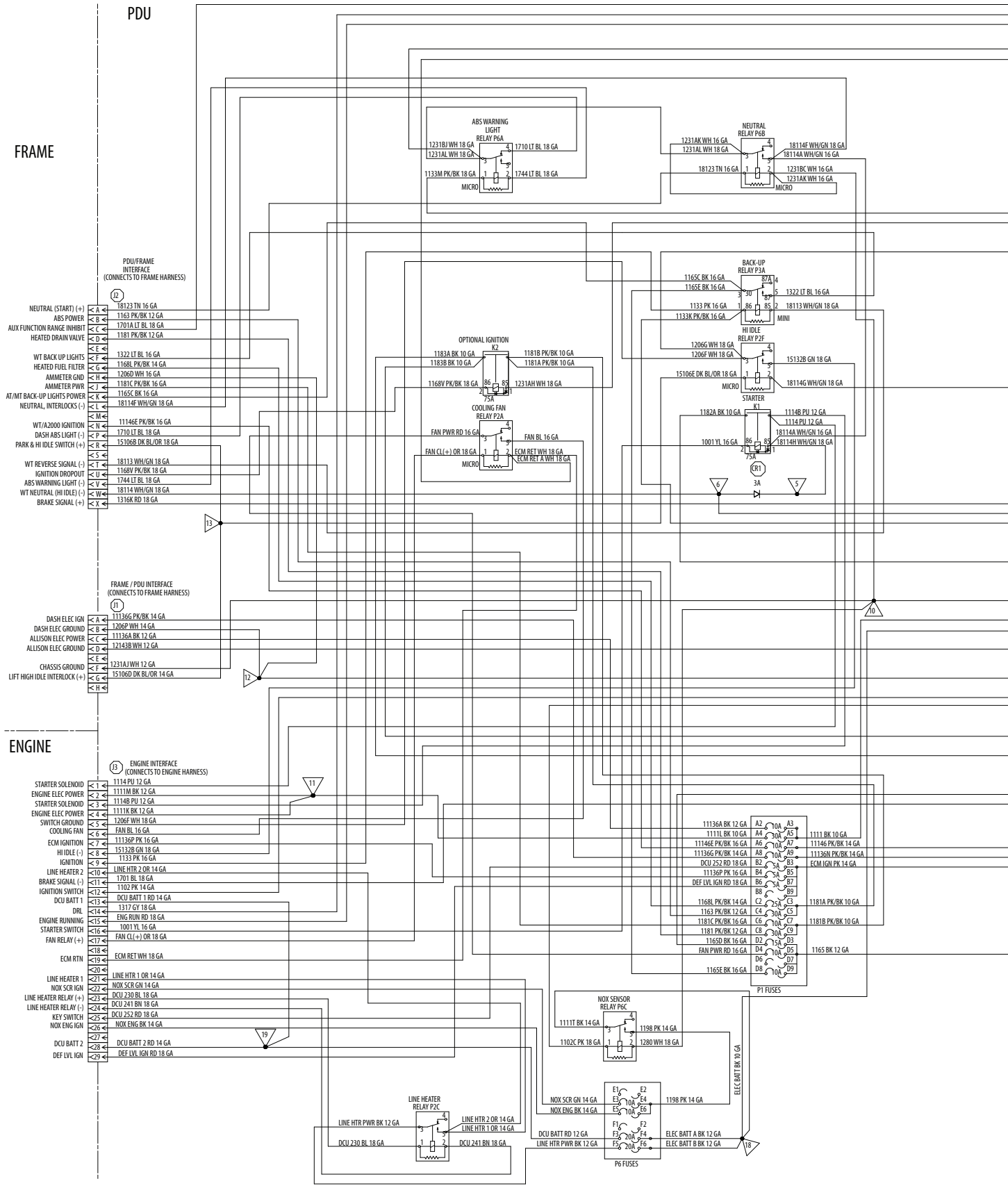
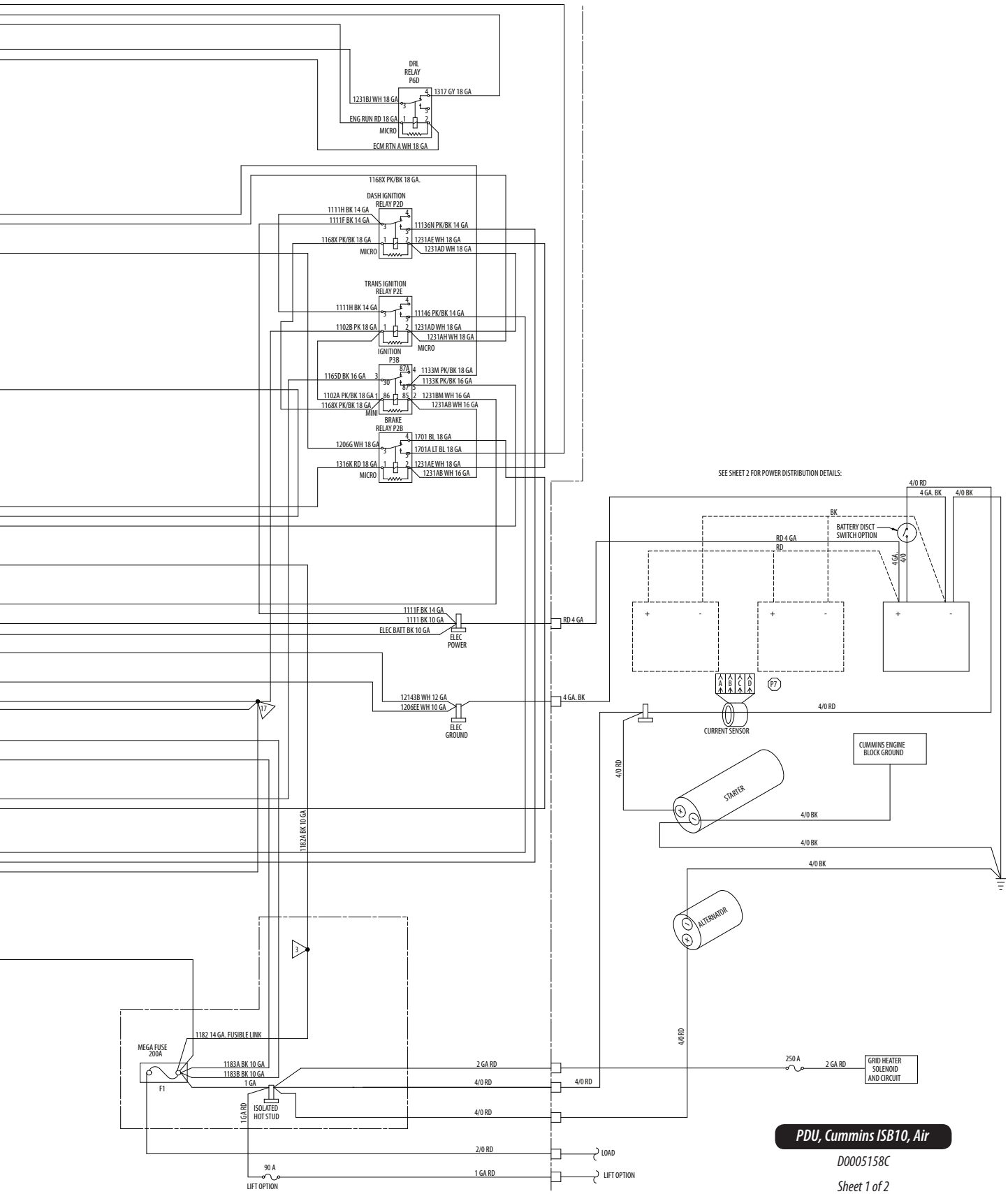

PDU
FRAME
ENGINE
PDU/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
NEUTRAL (START) (+) A 18123 TN 16 GA
ABS POWER B 1163 PK/BK 12 GA
AUX FUNCTION RANGE INHIBIT C 1701A LT BL 18 GA
HEATED DRAIN VALVE D 1181 PK/BK 12 GA
WT BACK UP LIGHTS F 1322 LT BL 16 GA
HEATED FUEL FILTER G 1168L PK/BK 14 GA
AMMETER GND H 1206D WH 16 GA
AMMETER PWR J 1181C PK/BK 16 GA
AT/MT BACK-UP LIGHTS POWER K 1165C BK 16 GA
NEUTRAL, INTERLOCKS (-) L 18114F WH/GN 18 GA
WT/A2000 IGNITION N 1114GE PK/BK 16 GA
DASH ABS LIGHT (-) P 1710 LT BL 18 GA
PARK & HI IDLE SWITCH (+) R 15106B DK BL/OR 18 GA
WT REVERSE SIGNAL (-) T 18113 WH/GN 18 GA
IGNITION DROPOUT U 1168V PK/BK 18 GA
ABS WARNING LIGHT (-) V 1744 LT BL 18 GA
WT NEUTRAL (HI IDLE) (-) W 18114 WH/GN 18 GA
BRAKE SIGNAL (+) X 1316K RD 18 GA
FRAME / PDU INTERFACE (CONNECTS TO FRAME HARNESS)
J1
DASH ELEC IGN A 11136G PK/BK 14 GA
DASH ELEC GROUND B 1206P WH 14 GA
ALLISON ELEC POWER C 11136A BK 12 GA
ALLISON ELEC GROUND D 12143B WH 12 GA
CHASSIS GROUND F 1231AJ WH 12 GA
LIFT HIGH IDLE INTERLOCK (+) G 15106D DK BL/OR 14 GA
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
J3
STARTER SOLENOID 1 1114 PU 12 GA
ENGINE ELEC POWER 2 1111M BK 12 GA
STARTER SOLENOID 3 1114B PU 12 GA
ENGINE ELEC POWER 4 1111K BK 12 GA
SWITCH GROUND 5 1206F WH 18 GA
COOLING FAN 6 FAN BL 16 GA
ECM IGNITION 7 11136P PK 16 GA
HI IDLE (-) 8 15132B GN 18 GA
IGNITION 9 1133 PK 16 GA
LINE HEATER 2 10 LINE HTR 2 OR 14 GA
BRAKE SIGNAL (-) 11 1701 BL 18 GA
IGNITION SWITCH 12 1102 PK 14 GA
DCU BATT 1 13 DCU BATT 1 RD 14 GA
DRL 14 1317 GY 18 GA
ENGINE RUNNING 15 ENG RUN RD 18 GA
STARTER SWITCH 16 1001 YL 16 GA
FAN RELAY (+) 17 FAN CL(+) OR 18 GA
ECM RTN 19 ECM RET WH 18 GA
LINE HEATER 1 21 LINE HTR 1 OR 14 GA
NOX SCR IGN 22 NOX SCR GN 14 GA
LINE HEATER RELAY (+) 23 DCU 230 BL 18 GA
LINE HEATER RELAY (-) 24 DCU 241 BN 18 GA
KEY SWITCH 25 DCU 252 RD 18 GA
NOX ENG IGN 26 NOX ENG BK 14 GA
DCU BATT 2 28 DCU BATT 2 RD 14 GA
DEF LVL IGN 29 DEF LVL IGN RD 18 GA
ABS WARNING LIGHT RELAY P6A
1231BJ WH 18 GA
1231AL WH 18 GA
1710 LT BL 18 GA
1133M PK/BK 18 GA
1744 LT BL 18 GA
MICRO
NEUTRAL RELAY P6B
1231AK WH 16 GA
1231AL WH 18 GA
18114F WH/GN 18 GA
18114A WH/GN 16 GA
18123 TN 16 GA
1231BC WH 16 GA
1231AK WH 16 GA
MICRO
BACK-UP RELAY P3A
1165C BK 16 GA
1165E BK 16 GA
1322 LT BL 16 GA
1133 PK 16 GA
1133K PK/BK 16 GA
18113 WH/GN 18 GA
MINI
OPTIONAL IGNITION K2
1183A BK 10 GA
1183B BK 10 GA
1181B PK/BK 10 GA
1181A PK/BK 10 GA
1168V PK/BK 18 GA
1231AH WH 18 GA
75A
HI IDLE RELAY P2F
1206G WH 18 GA
1206F WH 18 GA
15132B GN 18 GA
15106E DK BL/OR 18 GA
18114G WH/GN 18 GA
MICRO
STARTER K1
1182A BK 10 GA
1114B PU 12 GA
1114 PU 12 GA
18114A WH/GN 16 GA
1001 YL 16 GA
18114H WH/GN 18 GA
75A
COOLING FAN RELAY P2A
FAN PWR RD 16 GA
FAN BL 16 GA
FAN CL(+) OR 18 GA
ECM RET WH 18 GA
ECM RET A WH 18 GA
MICRO
CR1
3A
11136A BK 12 GA
1111L BK 10 GA
11146E PK/BK 16 GA
11136G PK/BK 14 GA
DCU 252 RD 18 GA
11136P PK 16 GA
DEF LVL IGN RD 18 GA
1168L PK/BK 14 GA
1163 PK/BK 12 GA
1181C PK/BK 16 GA
1181 PK/BK 12 GA
1165D BK 16 GA
FAN PWR RD 16 GA
1165E BK 16 GA
1111 BK 10 GA
11146 PK/BK 14 GA
11136N PK/BK 14 GA
ECM IGN PK 14 GA
1181A PK/BK 10 GA
1181B PK/BK 10 GA
1165 BK 12 GA
P1 FUSES
NOX SENSOR RELAY P6C
1111T BK 14 GA
1198 PK 14 GA
1102C PK 18 GA
1280 WH 18 GA
LINE HEATER RELAY P2C
LINE HTR PWR BK 12 GA
LINE HTR 2 OR 14 GA
LINE HTR 1 OR 14 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA
NOX SCR GN 14 GA
NOX ENG BK 14 GA
1198 PK 14 GA
DCU BATT RD 12 GA
LINE HTR PWR BK 12 GA
ELEC BATT A BK 12 GA
ELEC BATT B BK 12 GA
ELEC BATT BK 10 GA
P6 FUSES



PDU, Cummins ISB10, Air

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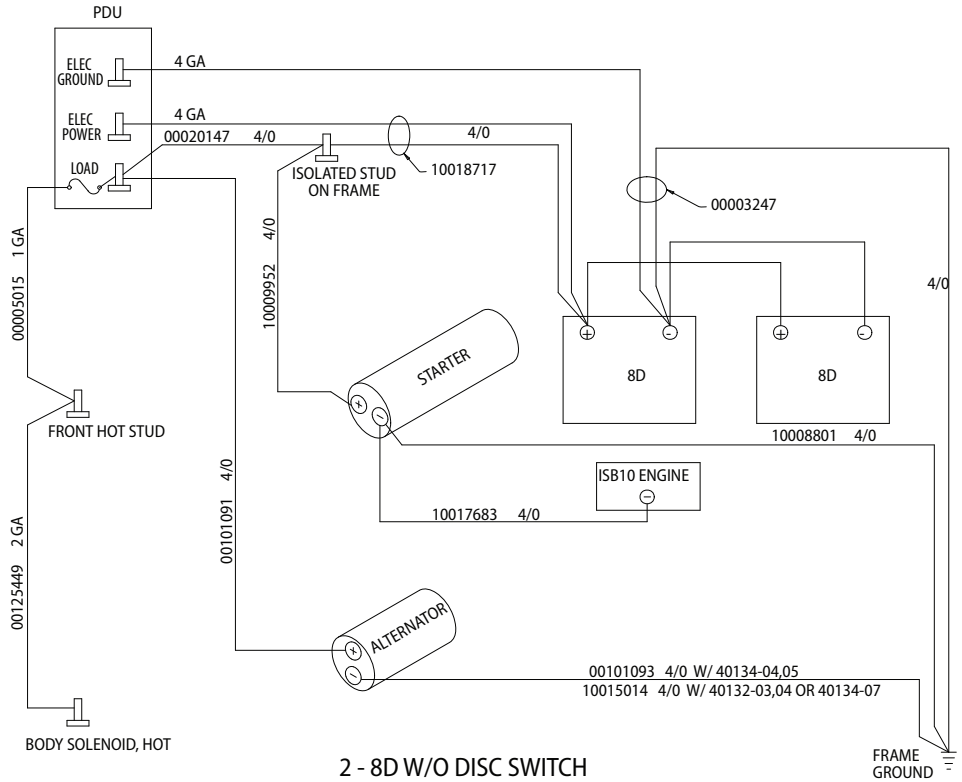
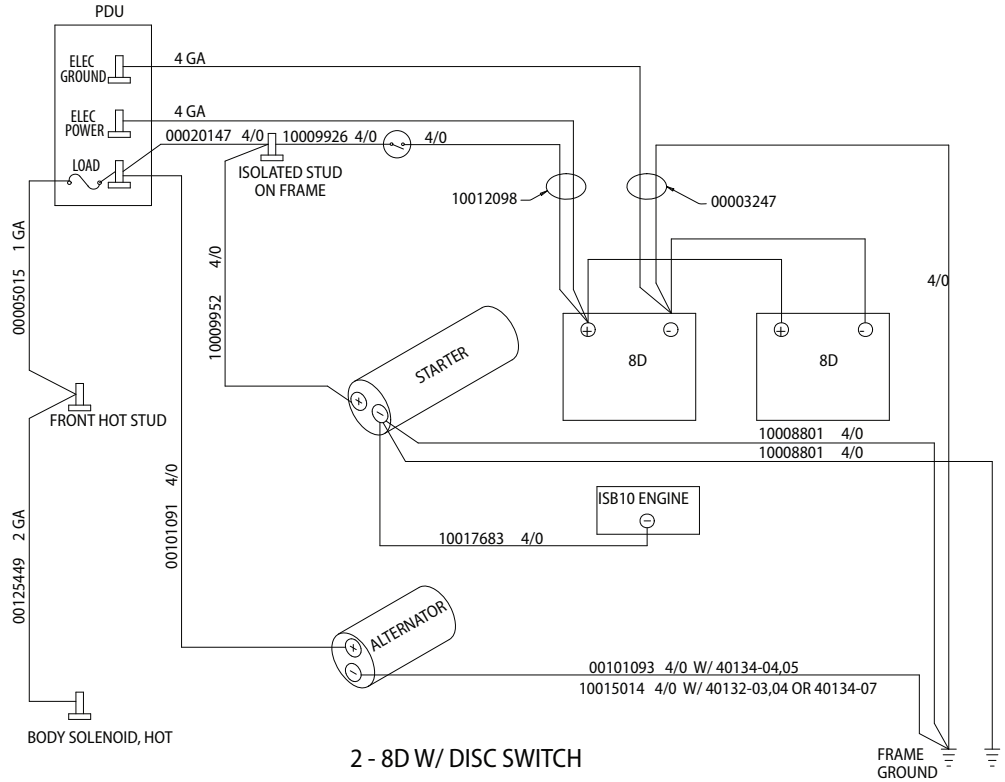
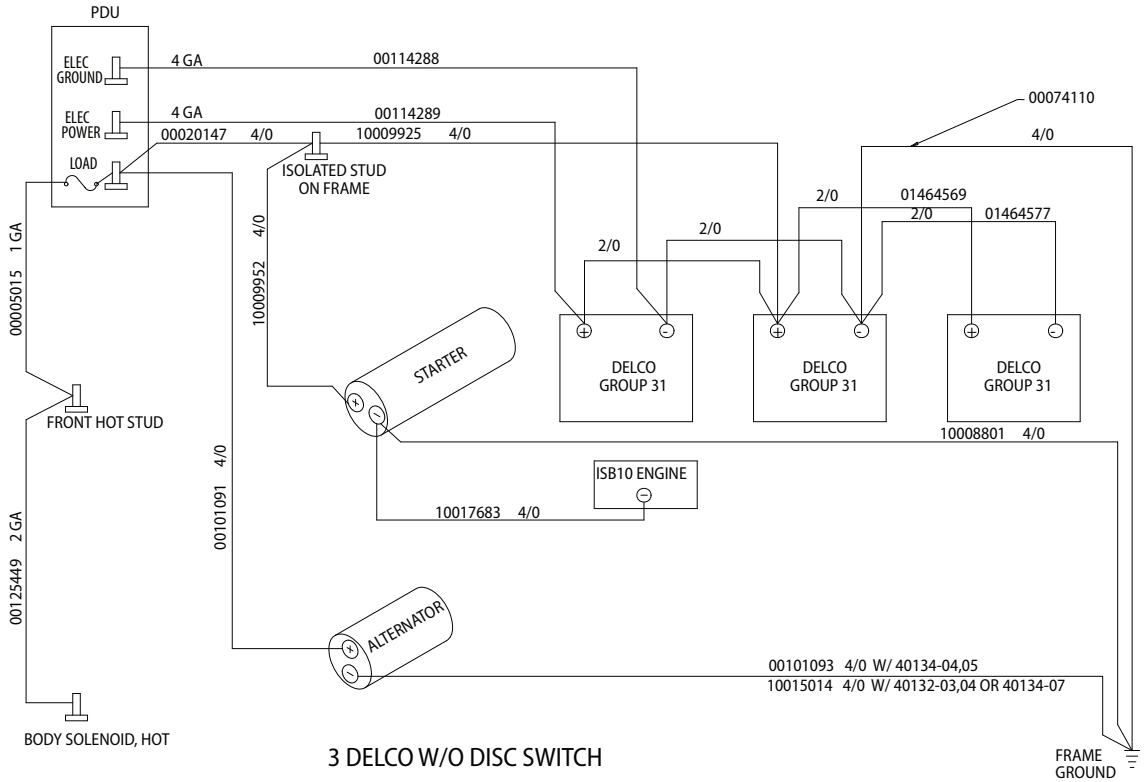


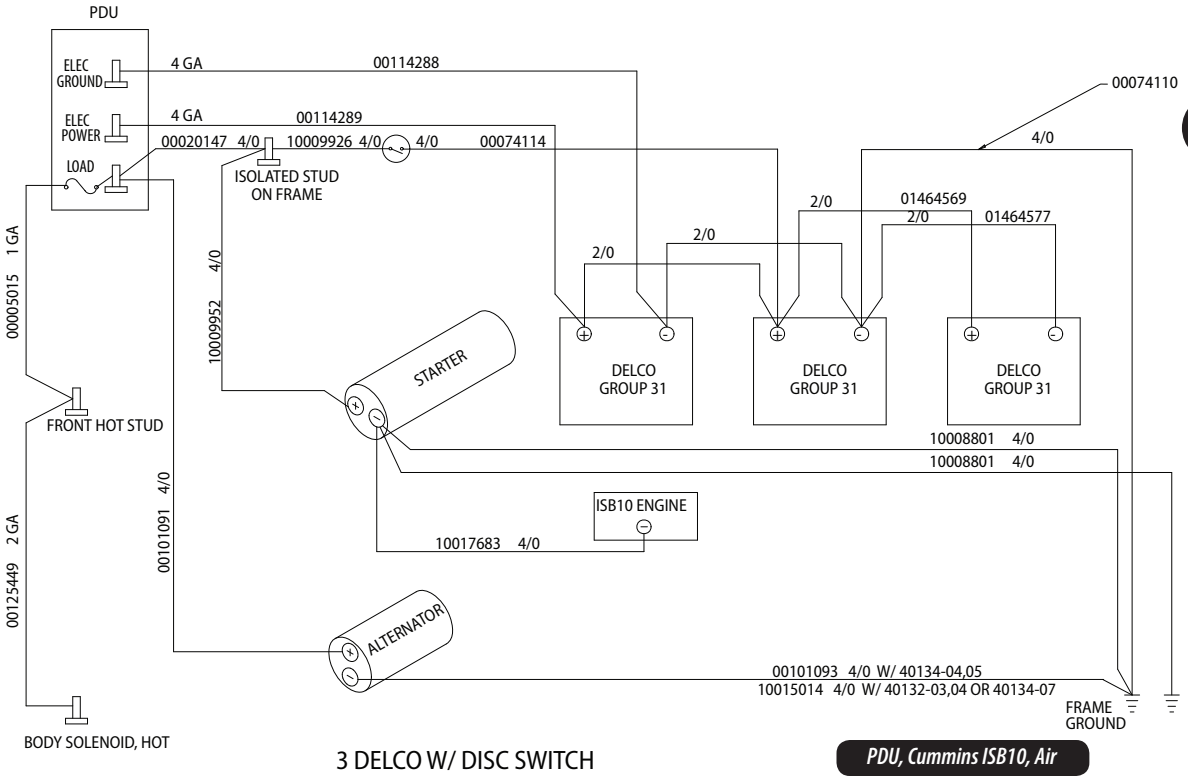
2 - 8D W/O DISC SWITCH



2 - 8D W/ DISC SWITCH



3 DELCO W/O DISC SWITCH



3 DELCO W/ DISC SWITCH

PDU, Cummins ISB10, Air

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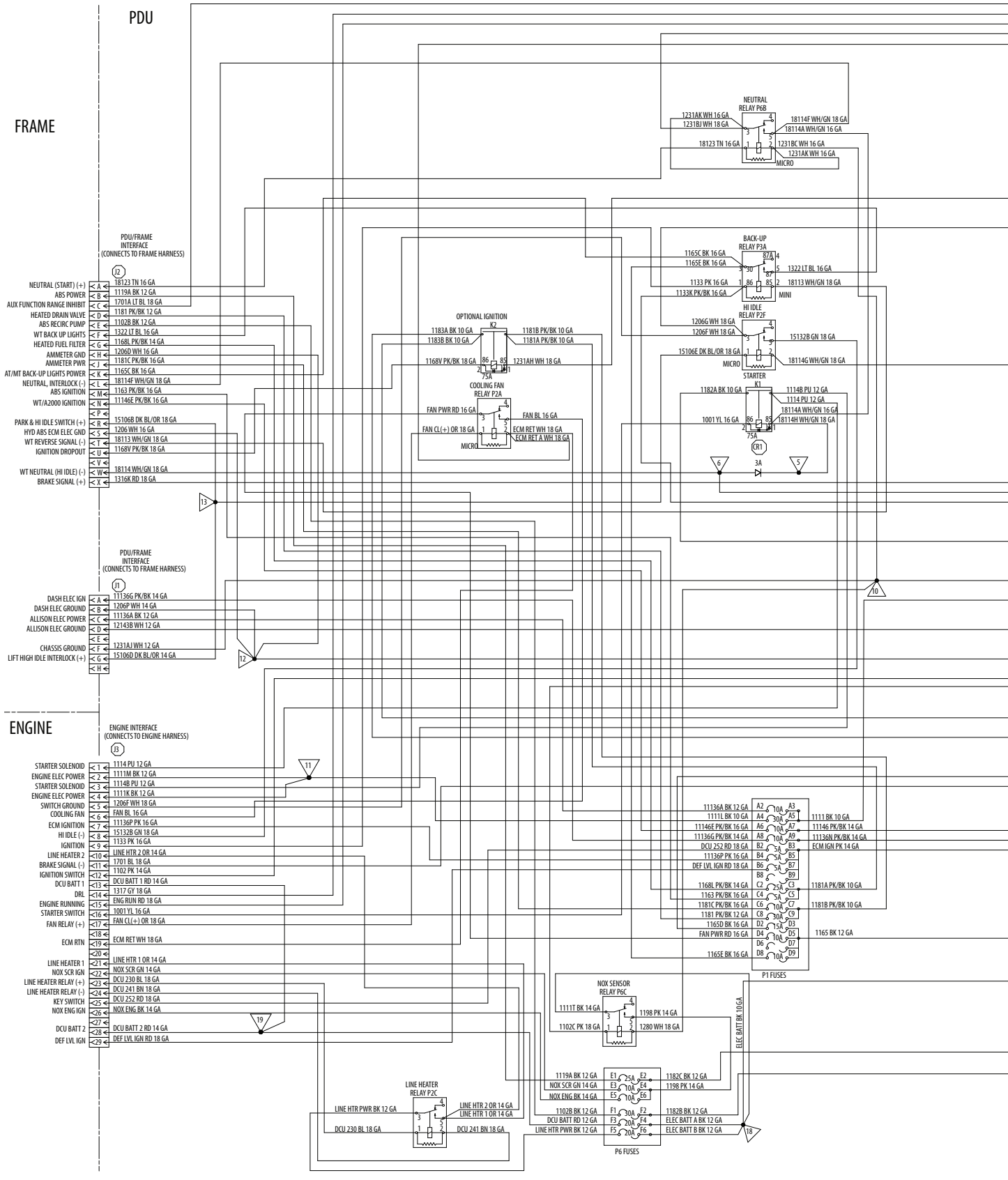
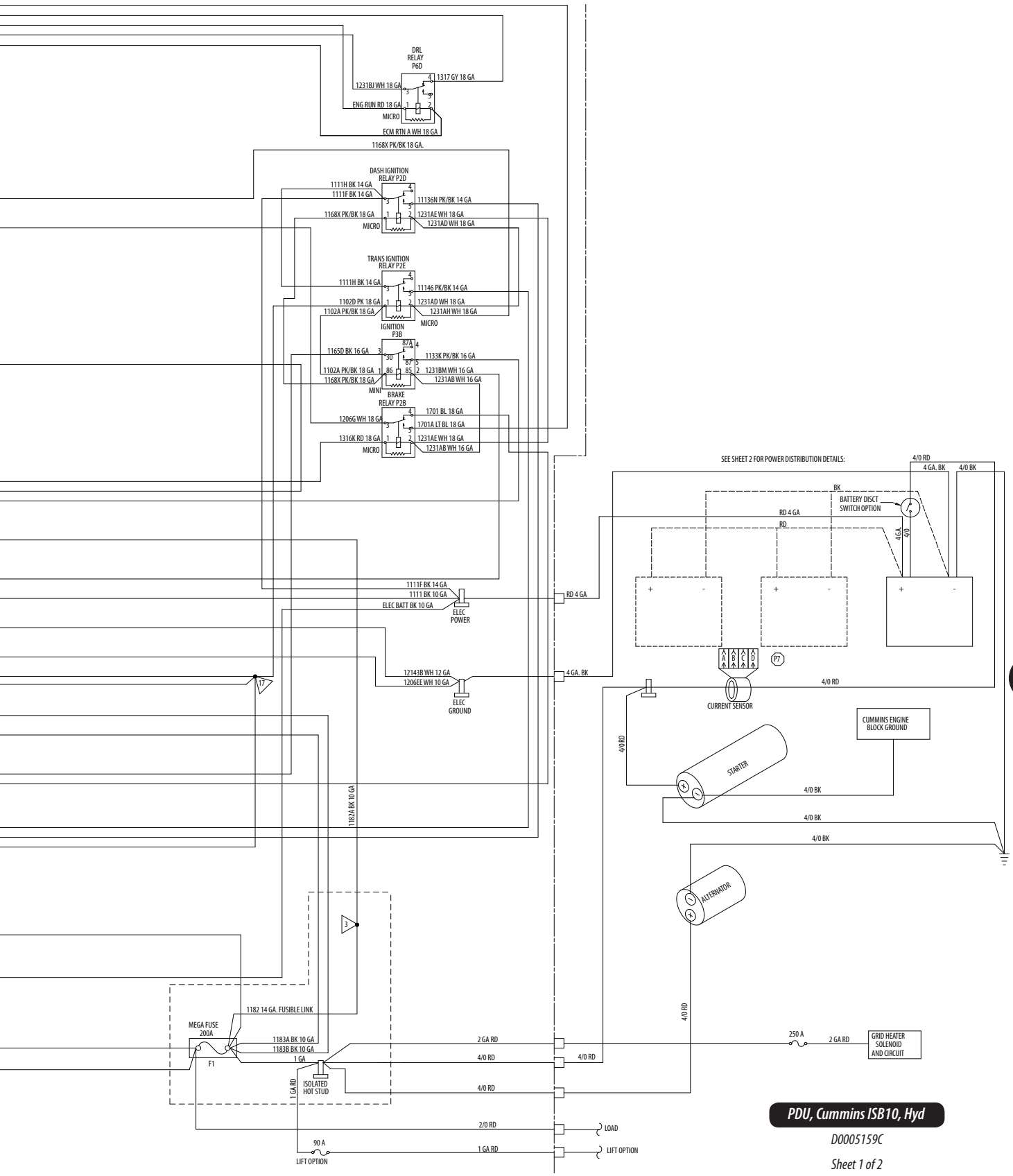
Sheet 2 of 2


PDU
FRAME
PDU/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J2
NEUTRAL (START) (+) A 18123 TN 16 GA
ABS POWER B 1119A BK 12 GA
AUX FUNCTION RANGE INHIBIT C 1701A LT BL 18 GA
HEATED DRAIN VALVE D 1181 PK/BK 12 GA
ABS RECIRC PUMP E 1102B BK 12 GA
WT BACK UP LIGHTS F 1322 LT BL 16 GA
HEATED FUEL FILTER G 1168L PK/BK 14 GA
AMMETER GND H 1206D WH 16 GA
AMMETER PWR J 1181C PK/BK 16 GA
AT/MT BACK-UP LIGHTS POWER K 1165C BK 16 GA
NEUTRAL, INTERLOCK (-) L 18114F WH/GN 18 GA
ABS IGNITION M 1163 PK/BK 16 GA
WT/A2000 IGNITION N 11146E PK/BK 16 GA
P
PARK & HI IDLE SWITCH (+) R 15106B DK BL/OR 18 GA
HYD ABS ECM ELEC GND S 1206 WH 16 GA
WT REVERSE SIGNAL (-) T 18113 WH/GN 18 GA
IGNITION DROPOUT U 1168V PK/BK 18 GA
V
WT NEUTRAL (HI IDLE) (-) W 18114 WH/GN 18 GA
BRAKE SIGNAL (+) X 1316K RD 18 GA
13
PDU/FRAME INTERFACE (CONNECTS TO FRAME HARNESS)
J1
DASH ELEC IGN A 11136G PK/BK 14 GA
DASH ELEC GROUND B 1206P WH 14 GA
ALLISON ELEC POWER C 1136A BK 12 GA
ALLISON ELEC GROUND D 12143B WH 12 GA
E
CHASSIS GROUND F 1231AJ WH 12 GA
LIFT HIGH IDLE INTERLOCK (+) G 15106D DK BL/OR 14 GA
H
12
878
ENGINE
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
J3
STARTER SOLENOID 1 1114 PU 12 GA
ENGINE ELEC POWER 2 1111M BK 12 GA
STARTER SOLENOID 3 1114B PU 12 GA
ENGINE ELEC POWER 4 1111K BK 12 GA
SWITCH GROUND 5 1206F WH 18 GA
COOLING FAN 6 FAN BL 16 GA
ECM IGNITION 7 11136P PK 16 GA
HI IDLE (-) 8 15132B GN 18 GA
IGNITION 9 1133 PK 16 GA
LINE HEATER 2 10 LINE HTR 2 OR 14 GA
BRAKE SIGNAL (-) 11 1701 BL 18 GA
IGNITION SWITCH 12 1102 PK 14 GA
DCU BATT 1 13 DCU BATT 1 RD 14 GA
DRL 14 1317 GY 18 GA
ENGINE RUNNING 15 ENG RUN RD 18 GA
STARTER SWITCH 16 1001 YL 16 GA
FAN RELAY (+) 17 FAN CL(+) OR 18 GA
18
ECM RTN 19 ECM RET WH 18 GA
20
LINE HEATER 1 21 LINE HTR 1 OR 14 GA
NOX SCR IGN 22 NOX SCR GN 14 GA
LINE HEATER RELAY (+) 23 DCU 230 BL 18 GA
LINE HEATER RELAY (-) 24 DCU 241 BN 18 GA
KEY SWITCH 25 DCU 252 RD 18 GA
NOX ENG IGN 26 NOX ENG BK 14 GA
27
DCU BATT 2 28 DCU BATT 2 RD 14 GA
DEF LVL IGN 29 DEF LVL IGN RD 18 GA
19
11
NEUTRAL RELAY P6B
1231AK WH 16 GA
1231BJ WH 18 GA
18123 TN 16 GA
18114F WH/GN 18 GA
18114A WH/GN 16 GA
1231BC WH 16 GA
1231AK WH 16 GA
MICRO
BACK-UP RELAY P3A
1165C BK 16 GA
1165E BK 16 GA
1322 LT BL 16 GA
1133 PK 16 GA
1133K PK/BK 16 GA
18113 WH/GN 18 GA
MINI
HI IDLE RELAY P2F
1206G WH 18 GA
1206F WH 18 GA
15132B GN 18 GA
15106E DK BL/OR 18 GA
18114G WH/GN 18 GA
MICRO
STARTER
K1
1182A BK 10 GA
1114B PU 12 GA
1114 PU 12 GA
18114A WH/GN 16 GA
1001 YL 16 GA
18114H WH/GN 18 GA
75A
CR1
3A
OPTIONAL IGNITION
K2
1183A BK 10 GA
1183B BK 10 GA
1181B PK/BK 10 GA
1181A PK/BK 10 GA
1168V PK/BK 18 GA
1231AH WH 18 GA
75A
COOLING FAN RELAY P2A
FAN PWR RD 16 GA
FAN BL 16 GA
FAN CL(+) OR 18 GA
ECM RET WH 18 GA
ECM RET A WH 18 GA
MICRO
10
11136A BK 12 GA
1111L BK 10 GA
11146E PK/BK 16 GA
11136G PK/BK 14 GA
DCU 252 RD 18 GA
11136P PK 16 GA
DEF LVL IGN RD 18 GA
1168L PK/BK 14 GA
1163 PK/BK 16 GA
1181C PK/BK 16 GA
1181 PK/BK 12 GA
1165D BK 16 GA
FAN PWR RD 16 GA
1165E BK 16 GA
1111 BK 10 GA
11146 PK/BK 14 GA
11136N PK/BK 14 GA
ECM IGN PK 14 GA
1181A PK/BK 10 GA
1181B PK/BK 10 GA
1165 BK 12 GA
P1 FUSES
NOX SENSOR RELAY P6C
1111T BK 14 GA
1198 PK 14 GA
1102C PK 18 GA
1280 WH 18 GA
ELEC BATT BK 10 GA
1119A BK 12 GA
NOX SCR GN 14 GA
NOX ENG BK 14 GA
1102B BK 12 GA
DCU BATT RD 12 GA
LINE HTR PWR BK 12 GA
1182C BK 12 GA
1198 PK 14 GA
1182B BK 12 GA
ELEC BATT A BK 12 GA
ELEC BATT B BK 12 GA
P6 FUSES
18
LINE HEATER RELAY P2C
LINE HTR PWR BK 12 GA
DCU 230 BL 18 GA
LINE HTR 2 OR 14 GA
LINE HTR 1 OR 14 GA
DCU 241 BN 18 GA



PDU, Cummins ISB10, Hyd

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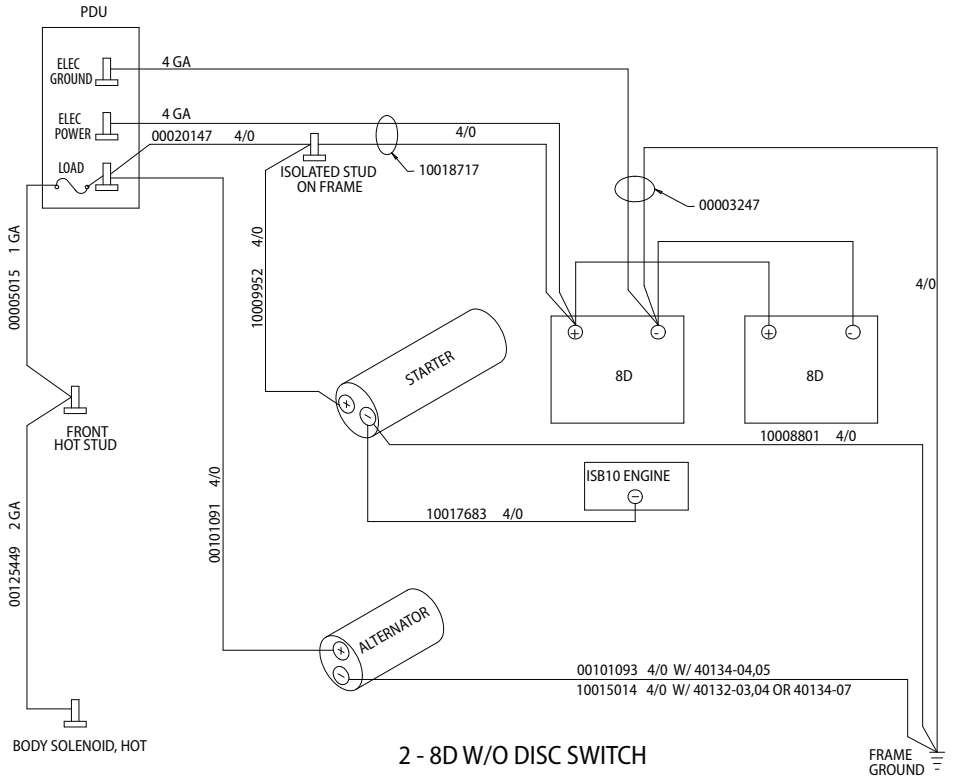
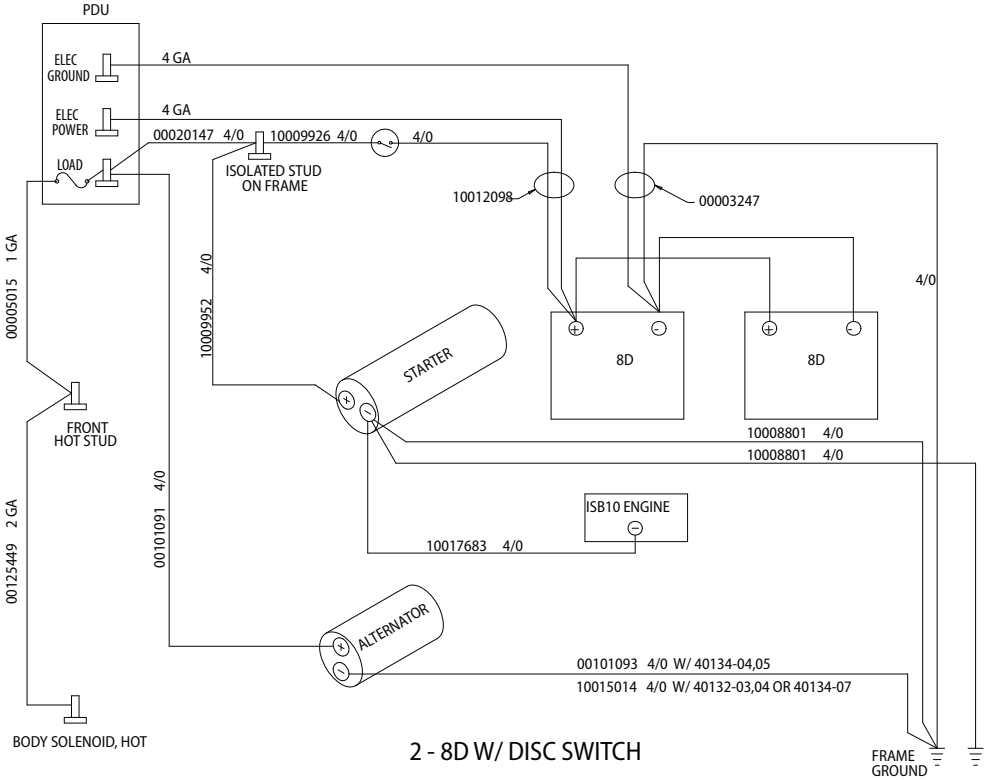
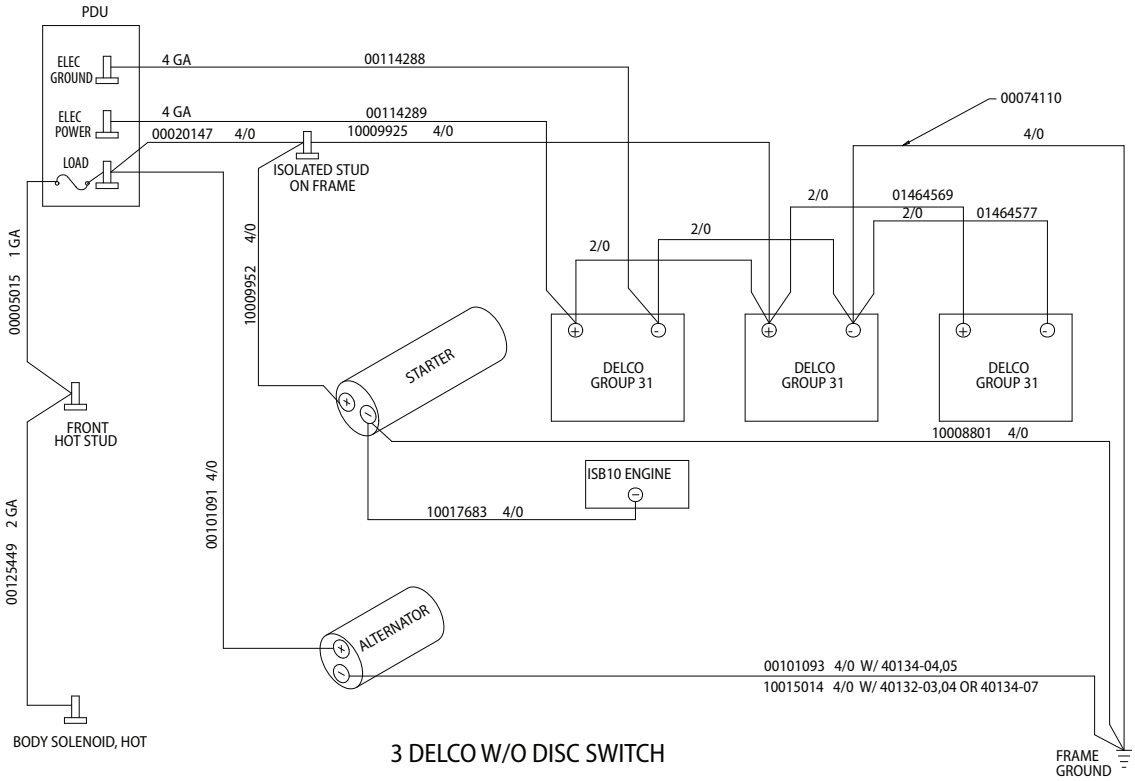
Sheet 1 of 2



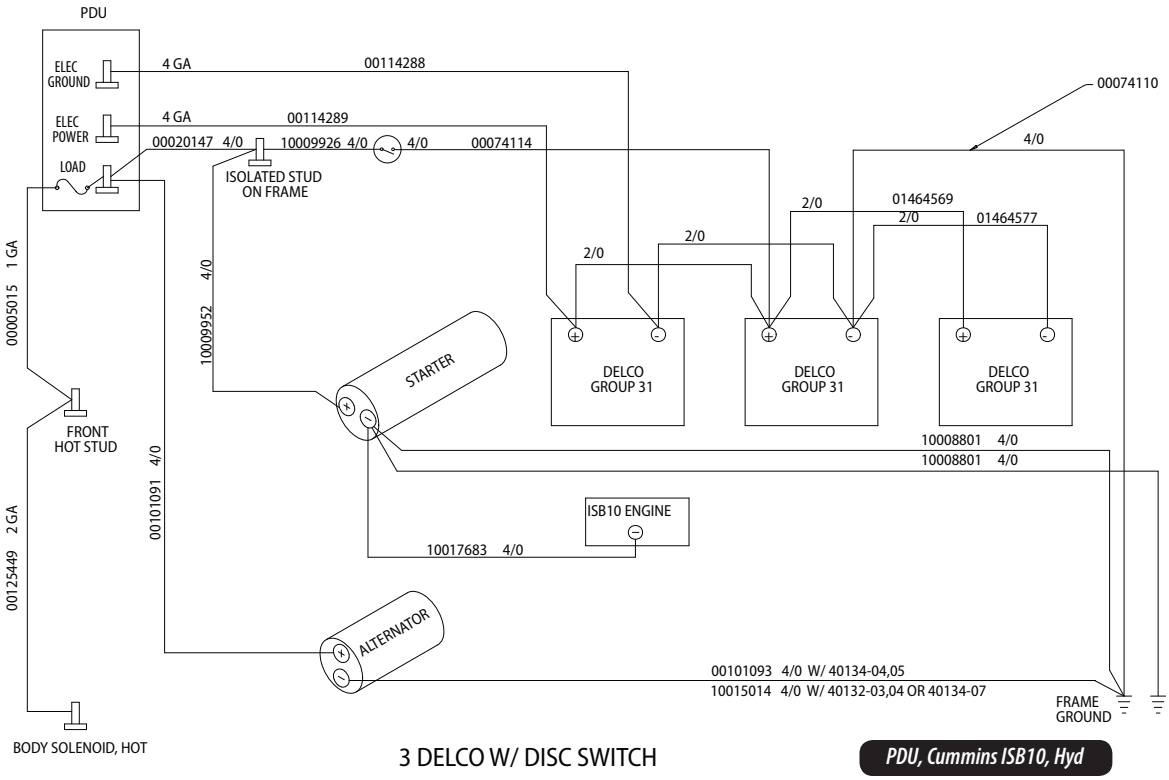
2 - 8D W/O DISC SWITCH



2 - 8D W/ DISC SWITCH



3 DELCO W/O DISC SWITCH



3 DELCO W/ DISC SWITCH

PDU, Cummins ISB10, Hyd

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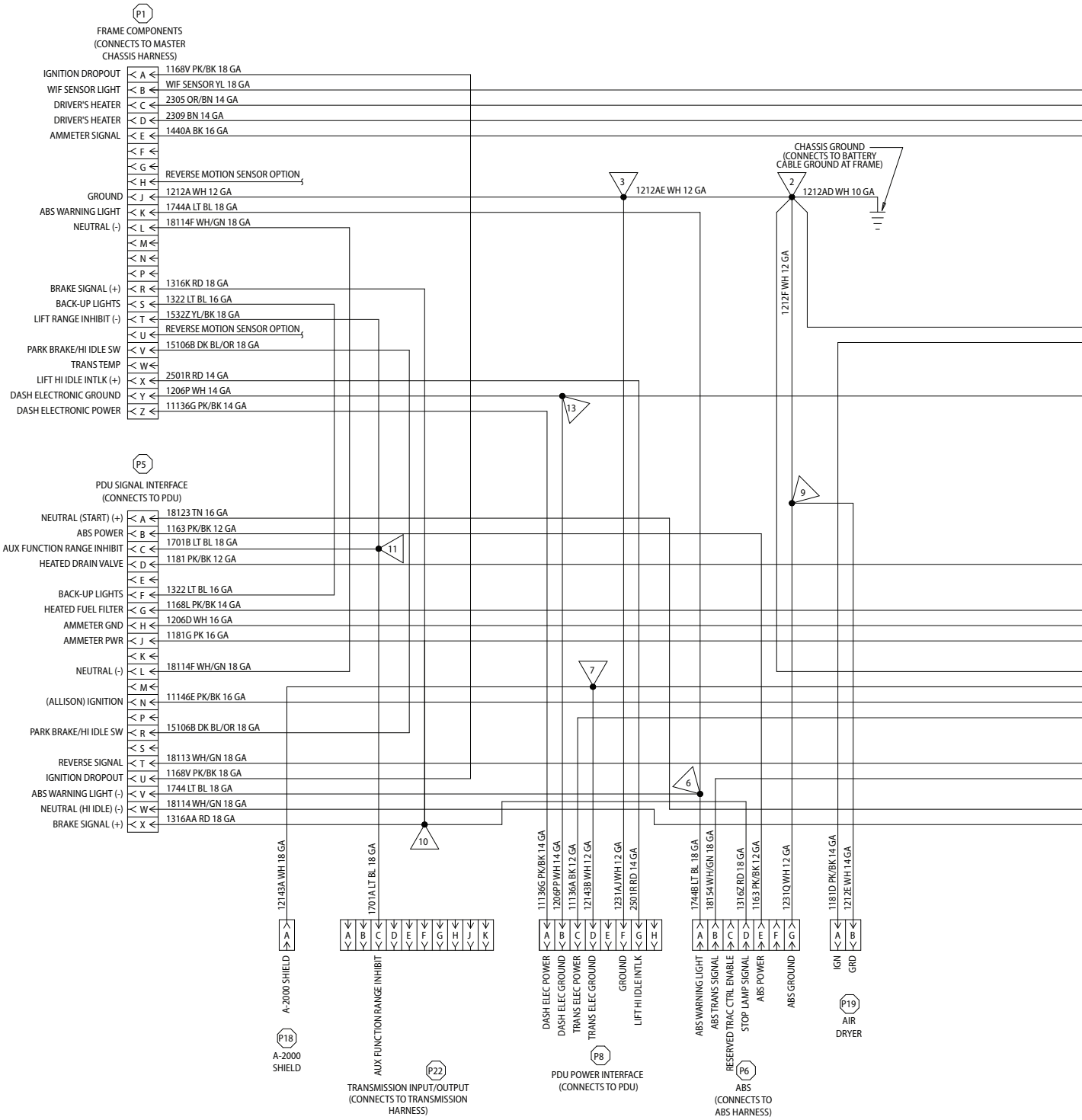
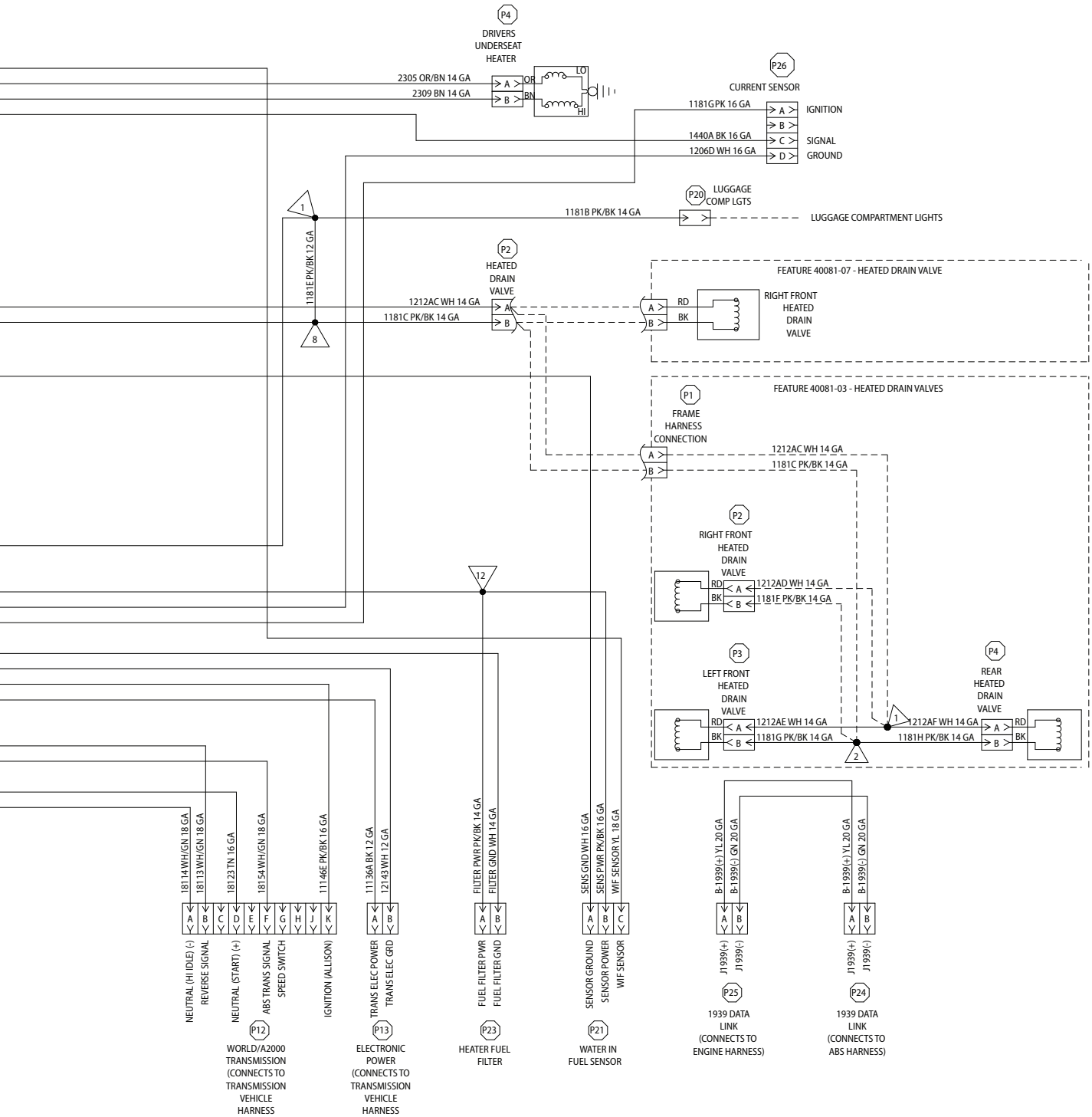
Sheet 2 of 2


P1
FRAME COMPONENTS
(CONNECTS TO MASTER
CHASSIS HARNESS)
IGNITION DROPOUT
WIF SENSOR LIGHT
DRIVER'S HEATER
DRIVER'S HEATER
AMMETER SIGNAL
GROUND
ABS WARNING LIGHT
NEUTRAL (-)
BRAKE SIGNAL (+)
BACK-UP LIGHTS
LIFT RANGE INHIBIT (-)
PARK BRAKE/HI IDLE SW
TRANS TEMP
LIFT HI IDLE INTLK (+)
DASH ELECTRONIC GROUND
DASH ELECTRONIC POWER
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
T
U
V
W
X
Y
Z
1168V PK/BK 18 GA
WIF SENSOR YL 18 GA
2305 OR/BN 14 GA
2309 BN 14 GA
1440A BK 16 GA
REVERSE MOTION SENSOR OPTION
1212A WH 12 GA
1744A LT BL 18 GA
18114F WH/GN 18 GA
1316K RD 18 GA
1322 LT BL 16 GA
1532Z YL/BK 18 GA
REVERSE MOTION SENSOR OPTION
15106B DK BL/OR 18 GA
2501R RD 14 GA
1206P WH 14 GA
11136G PK/BK 14 GA
CHASSIS GROUND
(CONNECTS TO BATTERY
CABLE GROUND AT FRAME)
1212AE WH 12 GA
1212AD WH 10 GA
1212F WH 12 GA
P5
PDU SIGNAL INTERFACE
(CONNECTS TO PDU)
NEUTRAL (START) (+)
ABS POWER
AUX FUNCTION RANGE INHIBIT
HEATED DRAIN VALVE
BACK-UP LIGHTS
HEATED FUEL FILTER
AMMETER GND
AMMETER PWR
NEUTRAL (-)
(ALLISON) IGNITION
PARK BRAKE/HI IDLE SW
REVERSE SIGNAL
IGNITION DROPOUT
ABS WARNING LIGHT (-)
NEUTRAL (HI IDLE) (-)
BRAKE SIGNAL (+)
18123 TN 16 GA
1163 PK/BK 12 GA
1701B LT BL 18 GA
1181 PK/BK 12 GA
1322 LT BL 16 GA
1168L PK/BK 14 GA
1206D WH 16 GA
1181G PK 16 GA
18114F WH/GN 18 GA
11146E PK/BK 16 GA
15106B DK BL/OR 18 GA
18113 WH/GN 18 GA
1168V PK/BK 18 GA
1744 LT BL 18 GA
18114 WH/GN 18 GA
1316AA RD 18 GA
3
2
9
13
11
7
6
10
12143A WH 18 GA
1701A LT BL 18 GA
11136G PK/BK 14 GA
1206PP WH 14 GA
11136A BK 12 GA
12143B WH 12 GA
1231AJ WH 12 GA
2501R RD 14 GA
1744B LT BL 18 GA
18154 WH/GN 18 GA
1316Z RD 18 GA
1163 PK/BK 12 GA
1231Q WH 12 GA
1181D PK/BK 14 GA
1212E WH 14 GA
A-2000 SHIELD
P18
A-2000
SHIELD
AUX FUNCTION RANGE INHIBIT
P22
TRANSMISSION INPUT/OUTPUT
(CONNECTS TO TRANSMISSION
HARNESS)
DASH ELEC POWER
DASH ELEC GROUND
TRANS ELEC POWER
TRANS ELEC GROUND
GROUND
LIFT HI IDLE INTLK
P8
PDU POWER INTERFACE
(CONNECTS TO PDU)
ABS WARNING LIGHT
ABS TRANS SIGNAL
RESERVED TRAC CTRL ENABLE
STOP LAMP SIGNAL
ABS POWER
ABS GROUND
P6
ABS
(CONNECTS TO
ABS HARNESS)
IGN
GRD
P19
AIR
DRYER



Frame, Air, Cummins ISB10

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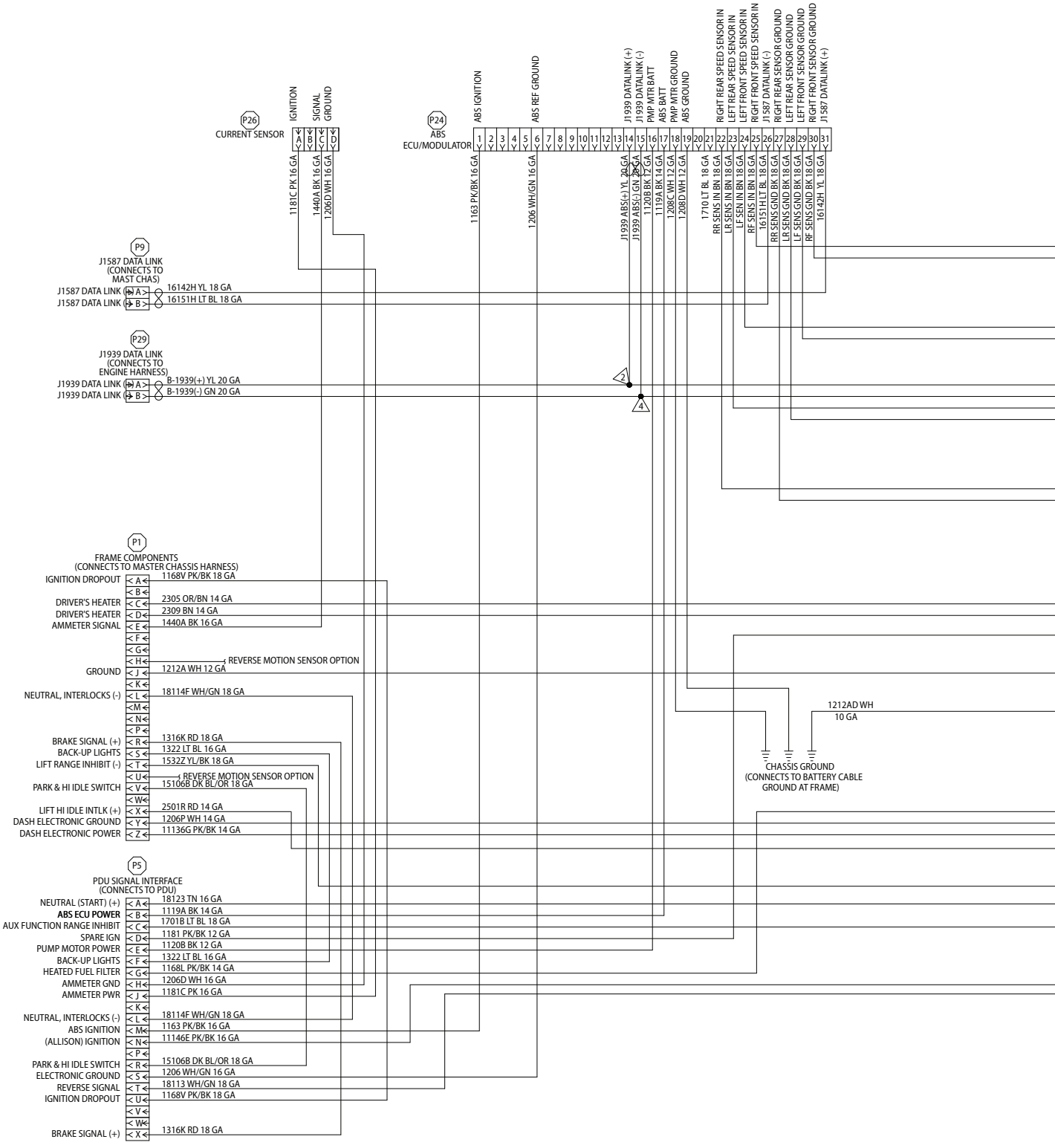
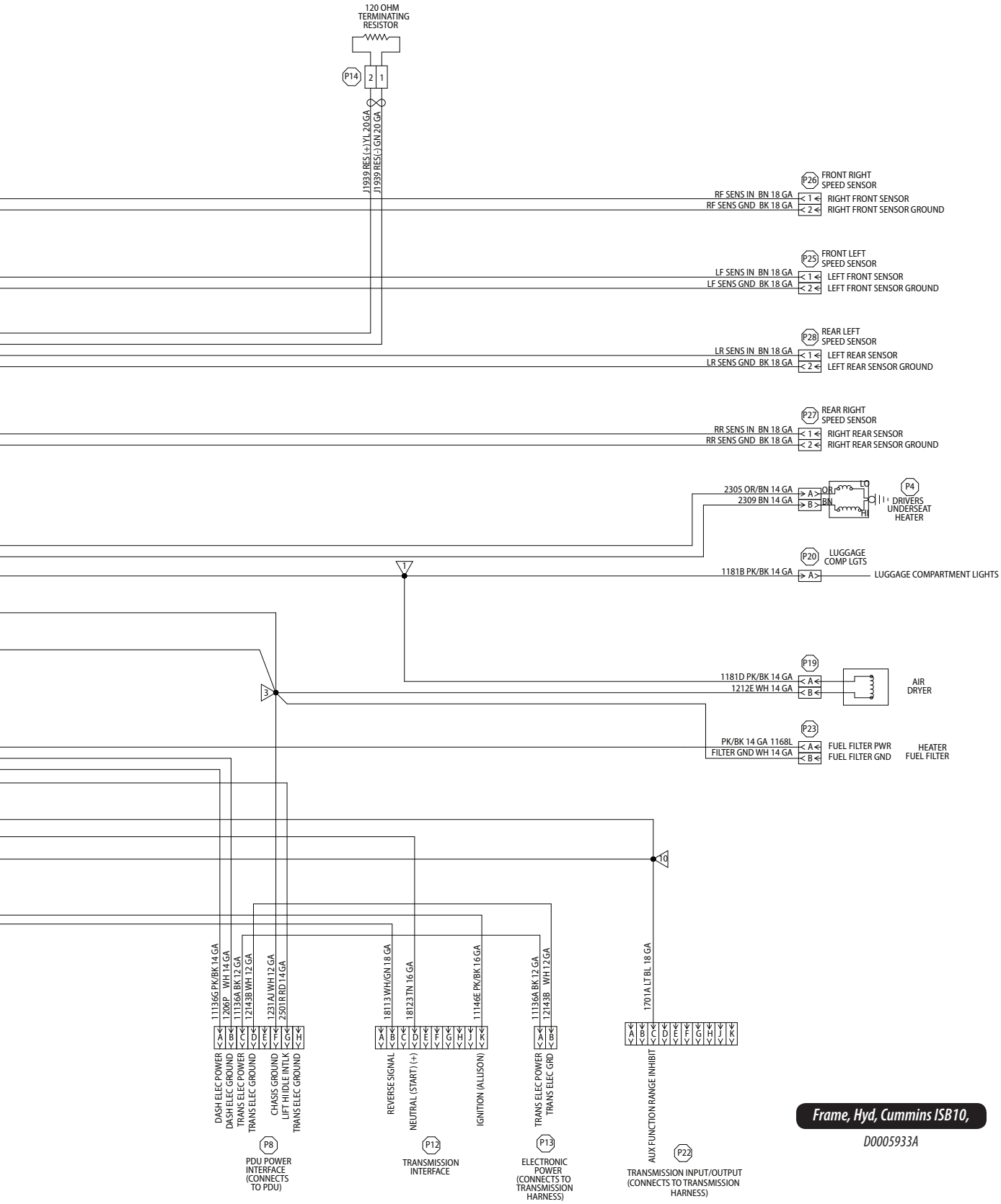

P26
CURRENT SENSOR
IGNITION
SIGNAL
GROUND
A
B
C
D
1181C PK 16 GA
1440A BK 16 GA
1206D WH 16 GA
P24
ABS
ECU/MODULATOR
ABS IGNITION
ABS REF GROUND
J1939 DATALINK (+)
J1939 DATALINK (-)
PMP MTR BATT
ABS BATT
PMP MTR GROUND
ABS GROUND
RIGHT REAR SPEED SENSOR IN
LEFT REAR SPEED SENSOR IN
LEFT FRONT SPEED SENSOR IN
RIGHT FRONT SPEED SENSOR IN
J1587 DATALINK (-)
RIGHT REAR SENSOR GROUND
LEFT REAR SENSOR GROUND
LEFT FRONT SENSOR GROUND
RIGHT FRONT SENSOR GROUND
J1587 DATALINK (+)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
1163 PK/BK 16 GA
1206 WH/GN 16 GA
J1939 ABS(+) YL 20 GA
J1939 ABS(-) GN 20 GA
1120B BK 12 GA
1119A BK 14 GA
1208C WH 12 GA
1208D WH 12 GA
1710 LT BL 18 GA
RR SENS IN BN 18 GA
LR SENS IN BN 18 GA
LF SEN IN BN 18 GA
RF SENS IN BN 18 GA
16151H LT BL 18 GA
RR SENS GND BK 18 GA
LR SENS GND BK 18 GA
LF SENS GND BK 18 GA
RF SENS GND BK 18 GA
16142H YL 18 GA
P9
J1587 DATA LINK
(CONNECTS TO
MAST CHAS)
J1587 DATA LINK (+)
J1587 DATA LINK (-)
A
B
16142H YL 18 GA
16151H LT BL 18 GA
P29
J1939 DATA LINK
(CONNECTS TO
ENGINE HARNESS)
J1939 DATA LINK (+)
J1939 DATA LINK (-)
A
B
B-1939(+) YL 20 GA
B-1939(-) GN 20 GA
2
4
P1
FRAME COMPONENTS
(CONNECTS TO MASTER CHASSIS HARNESS)
IGNITION DROPOUT
A
1168V PK/BK 18 GA
B
DRIVER'S HEATER
C
2305 OR/BN 14 GA
DRIVER'S HEATER
D
2309 BN 14 GA
AMMETER SIGNAL
E
1440A BK 16 GA
F
G
H
REVERSE MOTION SENSOR OPTION
GROUND
J
1212A WH 12 GA
K
NEUTRAL, INTERLOCKS (-)
L
18114F WH/GN 18 GA
M
N
P
BRAKE SIGNAL (+)
R
1316K RD 18 GA
BACK-UP LIGHTS
S
1322 LT BL 16 GA
LIFT RANGE INHIBIT (-)
T
1532Z YL/BK 18 GA
U
REVERSE MOTION SENSOR OPTION
PARK & HI IDLE SWITCH
V
15106B DK BL/OR 18 GA
W
LIFT HI IDLE INTLK (+)
X
2501R RD 14 GA
DASH ELECTRONIC GROUND
Y
1206P WH 14 GA
DASH ELECTRONIC POWER
Z
11136G PK/BK 14 GA
1212AD WH
10 GA
CHASSIS GROUND
(CONNECTS TO BATTERY CABLE
GROUND AT FRAME)
P5
PDU SIGNAL INTERFACE
(CONNECTS TO PDU)
NEUTRAL (START) (+)
A
18123 TN 16 GA
ABS ECU POWER
B
1119A BK 14 GA
AUX FUNCTION RANGE INHIBIT
C
1701B LT BL 18 GA
SPARE IGN
D
1181 PK/BK 12 GA
PUMP MOTOR POWER
E
1120B BK 12 GA
BACK-UP LIGHTS
F
1322 LT BL 16 GA
HEATED FUEL FILTER
G
1168L PK/BK 14 GA
AMMETER GND
H
1206D WH 16 GA
AMMETER PWR
J
1181C PK 16 GA
K
NEUTRAL, INTERLOCKS (-)
L
18114F WH/GN 18 GA
ABS IGNITION
M
1163 PK/BK 16 GA
(ALLISON) IGNITION
N
11146E PK/BK 16 GA
P
PARK & HI IDLE SWITCH
R
15106B DK BL/OR 18 GA
ELECTRONIC GROUND
S
1206 WH/GN 16 GA
REVERSE SIGNAL
T
18113 WH/GN 18 GA
IGNITION DROPOUT
U
1168V PK/BK 18 GA
V
W
BRAKE SIGNAL (+)
X
1316K RD 18 GA



Frame, Hyd, Cummins ISB10,

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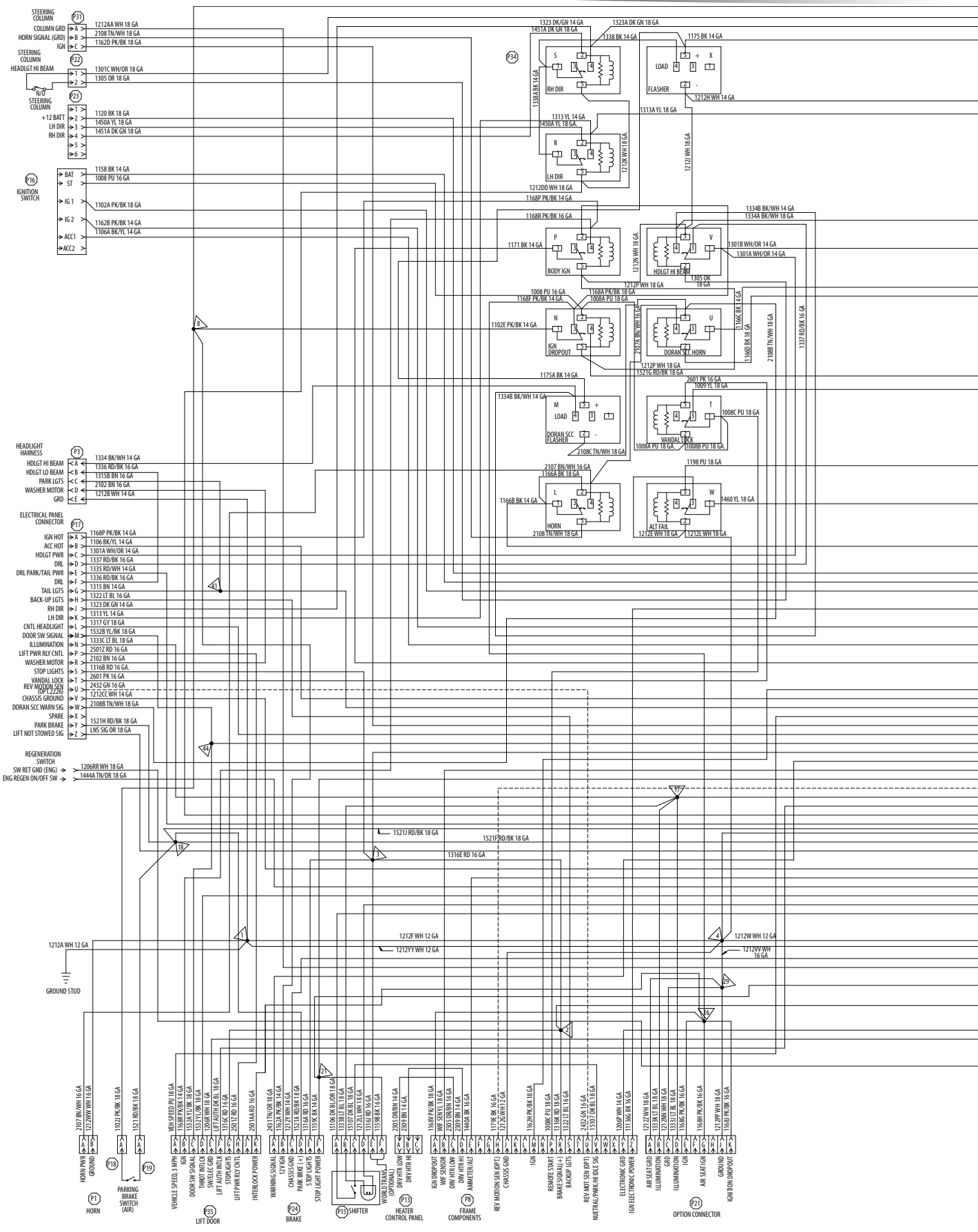
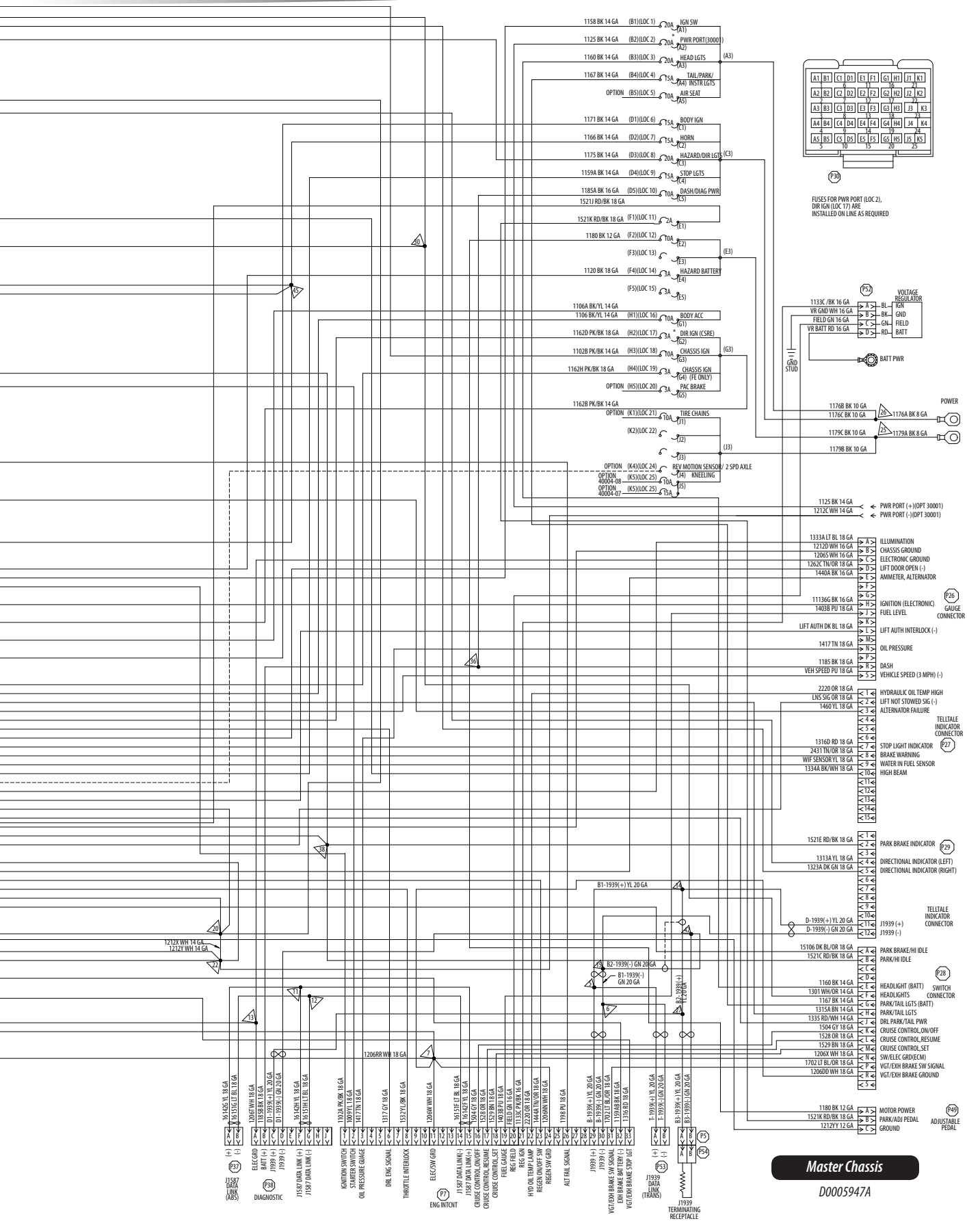

STEERING COLUMN P31
COLUMN GRD A 1212AA WH 18 GA
HORN SIGNAL (GRD) B 2108 TN/WH 18 GA
IGN C 1162D PK/BK 18 GA
STEERING COLUMN HEADLGT HI BEAM P22
1 1301C WH/OR 18 GA
2 1305 OR 18 GA
N/O
STEERING COLUMN P23
1 1120 BK 18 GA
+12 BATT 2 1450A YL 18 GA
LH DIR 3 1451A DK GN 18 GA
RH DIR 4
5
6
IGNITION SWITCH P16
BAT 1158 BK 14 GA
ST 1008 PU 16 GA
IG 1 1102A PK/BK 18 GA
IG 2 1162B PK/BK 14 GA
1106A BK/YL 14 GA
ACC1
ACC2
HEADLIGHT HARNESS P3
HDLGT HI BEAM A 1334 BK/WH 14 GA
HDLGT LO BEAM B 1336 RD/BK 16 GA
PARK LGTS C 1315B BN 16 GA
WASHER MOTOR D 2102 BN 16 GA
GRD E 1212B WH 14 GA
ELECTRICAL PANEL CONNECTOR P17
IGN HOT A 1168P PK/BK 14 GA
ACC HOT B 1106 BK/YL 14 GA
HDLGT PWR C 1301A WH/OR 14 GA
DRL D 1337 RD/BK 16 GA
DRL PARK/TAIL PWR E 1335 RD/WH 14 GA
DRL F 1336 RD/BK 16 GA
TAIL LGTS G 1315 BN 14 GA
BACK-UP LGTS H 1322 LT BL 16 GA
RH DIR J 1323 DK GN 14 GA
LH DIR K 1313 YL 14 GA
CNTL HEADLIGHT L 1317 GY 18 GA
DOOR SW SIGNAL M 1532B YL/BK 18 GA
ILLUMINATION N 1333C LT BL 18 GA
LIFT PWR RLY CNTL P 2501Z RD 16 GA
WASHER MOTOR R 2102 BN 16 GA
STOP LIGHTS S 1316B RD 16 GA.
VANDAL LOCK T 2601 PK 16 GA
REV MOTION SEN (OPT 2226) U 2432 GN 16 GA
CHASSIS GROUND V 1212CC WH 14 GA
DORAN SCC WARN SIG W 2108B TN/WH 18 GA
SPARE X 1521H RD/BK 18 GA
PARK BRAKE Y
LIFT NOT STOWED SIG Z LNS SIG OR 18 GA
REGENERATION SWITCH
SW RET GND (ENG) 1206RR WH 18 GA
ENG REGEN ON/OFF SW 1444A TN/OR 18 GA
1212A WH 12 GA
GROUND STUD
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
1212VV WH 16 GA
1521J RD/BK 18 GA
1521F RD/BK 18 GA
1316E RD 16 GA
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1175 BK 14 GA
1338A BK 14 GA
RH DIR
FLASHER
1212H WH 14 GA
1313 YL 14 GA
1450A YL 18 GA.
1313A YL 18 GA
1212Z WH 18 GA.
1212 WH 18 GA
LH DIR
1212DD WH 18 GA
1168P PK/BK 14 GA
1168R PK/BK 16 GA
1334B BK/WH 14 GA
1334A BK/WH 18 GA
1171 BK 14 GA
1212R WH 18 GA.
1301B WH/OR 14 GA
1301A WH/OR 14 GA
BODY IGN
HDLGT HI BEAM
1305 OR 18 GA
1212P WH 18 GA
1008 PU 16 GA
1168F PK/BK 14 GA.
1168A PK/BK 18 GA
1008A PU 18 GA
1102E PK/BK 14 GA
IGN DROPOUT
2107A BN/WH 16 GA
DORAN SCC HORN
1166C BK 14 GA
1166D BK 18 GA
2108B TN/WH 18 GA
1337 RD/BK 16 GA
1212P WH 18 GA
1521G RD/BK 18 GA
1175A BK 14 GA
2601 PK 16 GA
1009 YL 18 GA
1334B BK/WH 14 GA
LOAD
DORAN SCC FLASHER
1008C PU 18 GA
VANDAL LOCK
1008A PU 18 GA.
1008B PU 18 GA.
2108C TN/WH 18 GA
2107 BN/WH 16 GA
1166A BK 18 GA
1198 PU 18 GA
1166B BK 14 GA
1460 YL 18 GA
HORN
2108 TN/WH 18 GA
ALT FAIL
1212E WH 18 GA
1212L WH 18 GA
2107 BN/WH 16 GA
1212AWW WH 16 GA
1102J PK/BK 18 GA
1521J RD/BK 18 GA
VEH SPEED, 3 MPH
IGN
DOOR SW SIGNAL
THROT INTLCK
SW/ELEC GRD
LIFT AUTH INTLK
STOPLIGHTS
LIFT PWR RLY CNTL
INTERLOCK POWER
WARNING SIGNAL
12V IGN
CHASSIS GND
PARK BRKE (+)
STOP LIGHTS
STOP LIGHT POWER
IGN DROPOUT
VHF SENSOR
DRV HTR LOW
DRV HTR HI
AMMETER/ALT
CHASSIS GND
IGN
REMOTE START
BRAKE SIGNAL(+)
BACKUP LGTS
REV MOT SEN (OPT)
NEUTRAL/PARK/HI IDLE SIG
ELECTRONIC GRD
IGN ELECTRONIC POWER
AIR SEAT GRD
ILLUMINATION
GRD
IGN
AIR SEAT IGN
GROUND
IGN TWN DROPOUT
HORN PWR
GROUND
HORN
P1
P18
P19
PARKING BRAKE SWITCH (AIR)
P35
LIFT DOOR
P24
BRAKE
P15
SHIFTER
P13
HEATER CONTROL PANEL
P9
FRAME COMPONENTS
P21
OPTION CONNECTOR
P34



Master Chassis

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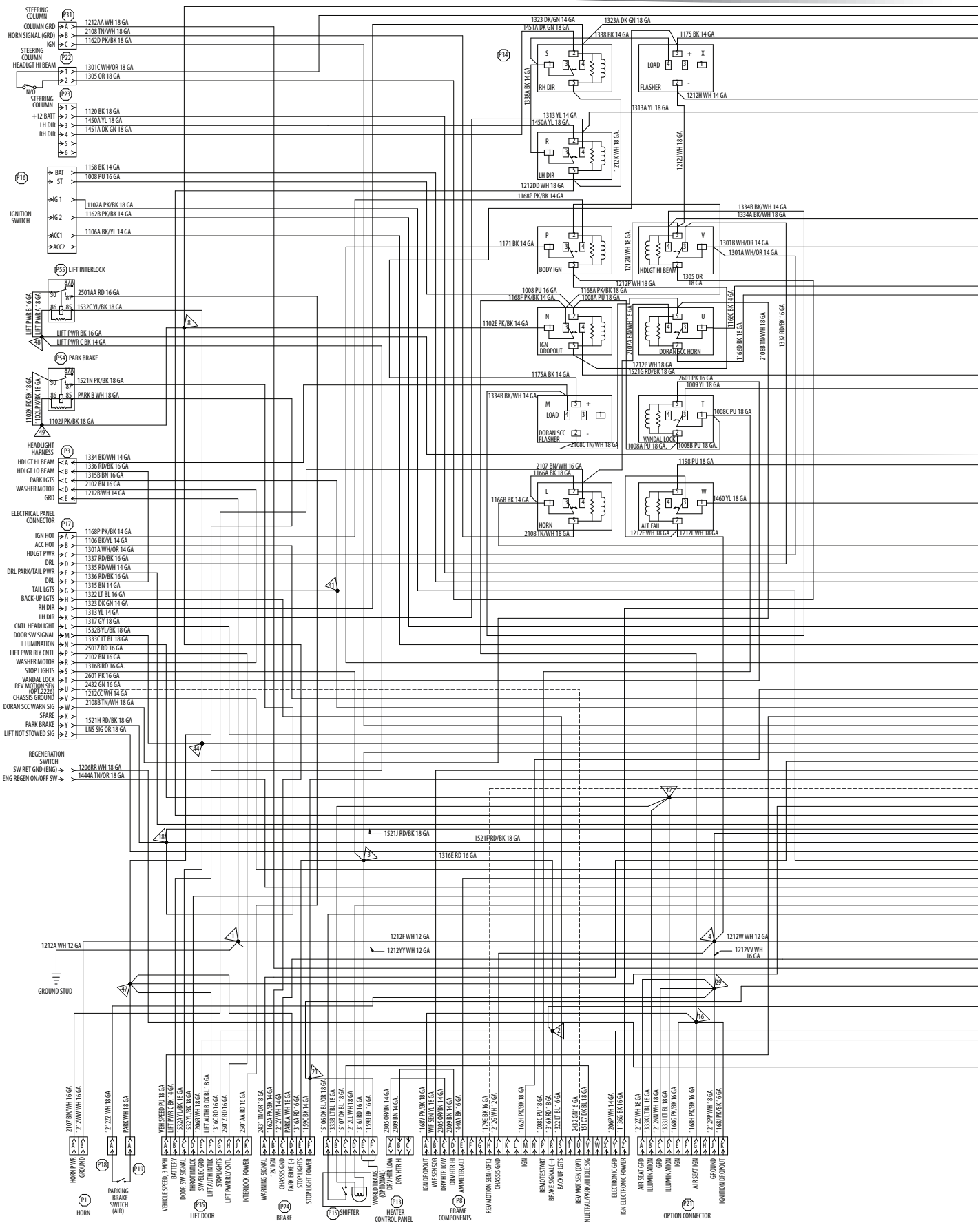
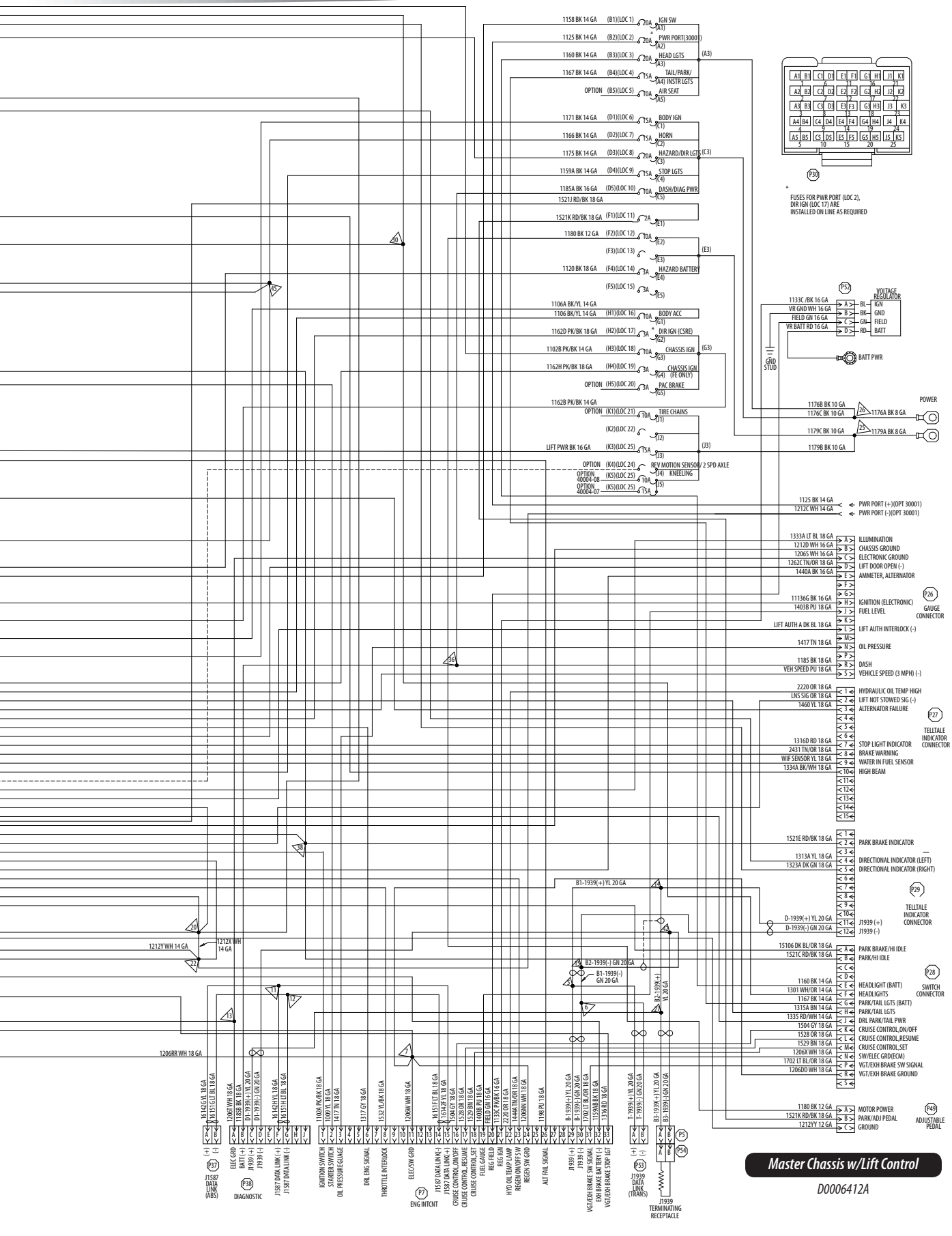

STEERING COLUMN
P31
COLUMN GRD
HORN SIGNAL (GRD)
IGN
1212AA WH 18 GA
2108 TN/WH 18 GA
1162D PK/BK 18 GA
STEERING COLUMN HEADLGT HI BEAM
P22
1301C WH/OR 18 GA
1305 OR 18 GA
N/O
STEERING COLUMN
P23
+12 BATT
LH DIR
RH DIR
1120 BK 18 GA
1450A YL 18 GA
1451A DK GN 18 GA
P16
BAT
ST
IG 1
IG 2
ACC1
ACC2
IGNITION SWITCH
1158 BK 14 GA
1008 PU 16 GA
1102A PK/BK 18 GA
1162B PK/BK 14 GA
1106A BK/YL 14 GA
P55 LIFT INTERLOCK
2501AA RD 16 GA
1532C YL/BK 18 GA
LIFT PWR A 16 GA
LIFT PWR B 16 GA
LIFT PWR BK 16 GA
LIFT PWR C BK 14 GA
P54 PARK BRAKE
1521N PK/BK 18 GA
PARK B WH 18 GA
1102K PK/BK 18 GA
1102J PK/BK 18 GA
HEADLIGHT HARNESS
P3
HDLGT HI BEAM
HDLGT LO BEAM
PARK LGTS
WASHER MOTOR
GRD
1334 BK/WH 14 GA
1336 RD/BK 16 GA
1315B BN 16 GA
2102 BN 16 GA
1212B WH 14 GA
ELECTRICAL PANEL CONNECTOR
P17
IGN HOT
ACC HOT
HDLGT PWR
DRL
DRL PARK/TAIL PWR
DRL
TAIL LGTS
BACK-UP LGTS
RH DIR
LH DIR
CNTL HEADLIGHT
DOOR SW SIGNAL
ILLUMINATION
LIFT PWR RLY CNTL
WASHER MOTOR
STOP LIGHTS
VANDAL LOCK
REV MOTION SEN (OPT 2226)
CHASSIS GROUND
DORAN SCC WARN SIG
SPARE
PARK BRAKE
LIFT NOT STOWED SIG
1168P PK/BK 14 GA
1106 BK/YL 14 GA
1301A WH/OR 14 GA
1337 RD/BK 16 GA
1335 RD/WH 14 GA
1336 RD/BK 16 GA
1315 BN 14 GA
1322 LT BL 16 GA
1323 DK GN 14 GA
1313 YL 14 GA
1317 GY 18 GA
1532B YL/BK 18 GA
1333C LT BL 18 GA
2501Z RD 16 GA
2102 BN 16 GA
1316B RD 16 GA.
2601 PK 16 GA
2432 GN 16 GA
1212C WH 14 GA
2108B TN/WH 18 GA
1521H RD/BK 18 GA
LNS SIG OR 18 GA
REGENERATION SWITCH
SW RET GND (ENG)
ENG REGEN ON/OFF SW
1206RR WH 18 GA
1444A TN/OR 18 GA
1212A WH 12 GA
GROUND STUD
1323 DK/GN 14 GA
1451A DK GN 18 GA
1323A DK GN 18 GA
1338 BK 14 GA
1175 BK 14 GA
P34
S
RH DIR
LOAD
FLASHER
1212H WH 14 GA
1313A YL 18 GA
1313 YL 14 GA
1450A YL 18 GA
R
LH DIR
1212K WH 18 GA.
1212J WH 18 GA
1212DD WH 18 GA
1168P PK/BK 14 GA
1334B BK/WH 14 GA
1334A BK/WH 18 GA
P
BODY IGN
1171 BK 14 GA
1212R WH 18 GA
V
HDLGT HI BEAM
1301B WH/OR 14 GA
1301A WH/OR 14 GA
1305 OR 18 GA
1212P WH 18 GA
1008 PU 16 GA
1168F PK/BK 14 GA.
1168A PK/BK 18 GA
1008A PU 18 GA
N
IGN DROPOUT
1102E PK/BK 14 GA
U
DORAN SCC HORN
2107A BN/WH 16 GA
1166G BK 18 GA
1166F BK 14 GA
2108B TN/WH 18 GA
1337 RD/BK 16 GA
1212P WH 18 GA
1521G RD/BK 18 GA
1175A BK 14 GA
2601 PK 16 GA
1009 YL 18 GA
1334B BK/WH 14 GA
M
LOAD
DORAN SCC FLASHER
2108C TN/WH 18 GA
T
VANDAL LOCK
1008C PU 18 GA
1008A PU 18 GA.
1008B PU 18 GA.
2107 BN/WH 16 GA
1166A BK 18 GA
L
HORN
1166B BK 14 GA
2108 TN/WH 18 GA
1198 PU 18 GA
W
ALT FAIL
1460 YL 18 GA
1212E WH 18 GA
1212L WH 18 GA
1521J RD/BK 18 GA
1521FRD/BK 18 GA
1316E RD 16 GA
1212F WH 12 GA
1212YY WH 12 GA
1212W WH 12 GA
1212VV WH 16 GA
2107 BN/WH 16 GA
12 GA
HORN PWR
GROUND
P1 HORN
12122Z WH 18 GA
PARK WH 18 GA
P18
P19
PARKING BRAKE SWITCH (AIR)
VEH SPEED PU 18 GA
LIFT PWR C BK 14 GA
152A LT GRN 18 GA
120M LT WH 18 GA
SW/ELEC GRD
LIFT AUTH IN TLK
STOP LGHTS
LIFT PWR RLY CNTL
P35 LIFT DOOR
2501A RD 16 GA
2431 BN/OR 18 GA
1162A PK/BK 14 GA
12122Y WH 14 GA
PARK A WH 18 GA
13164 RD 16 GA
1159K BK 14 GA
P24 BRAKE
INTERLOCK POWER
WARNING SIGNAL
12V IGN
CHASSIS GND
PARK BRKE (-)
STOP LIGHTS
STOP LIGHT POWER
15106 DK BL/OR 18 GA
13381 LT BL 18 GA
15107 DK BL 18 GA
12121 WH 18 GA
13161 RD 16 GA
11598 BK 16 GA
P15 SHIFTER
WORLD TRANS (OPTIONAL)
DRIVE LOW
DRIVE HTR HI
2305 GN/BN 14 GA
2309 BN 14 GA.
P13 HEATER CONTROL PANEL
1168W PK/BK 18 GA
WIF SENSOR
DRIV HTR LOW
DRIV HTR HI
AMMETER/ALT
2305 GN/BN 14 GA.
2309 BN 14 GA
14404 BK 16 GA
P8 FRAME COMPONENTS
IGN DROPOUT
WIF SEN SOR
DRIV HTR LOW
DRIV HTR HI
AMMETER/ALT
1179E BK 16 GA
12265 WH 12 GA
CHASSIS GND
REV MOTION SEN (OPT)
1162H PK/BK 18 GA.
IGN
1008C PU 18 GA
1316A RD 18 GA
1322 LT BL 16 GA
REMOTE START
BRAKE SIGNAL (+)
BACKUP LGTS
2432 GN 16 GA
15107 DK BL 18 GA
REV MOT SEN (OPT)
NUETRAL/PARK/HI IDLE SIG
1206P WH 14 GA
11139G BR 16 GA
ELECTRONIC GRD
IGN ELECTRONIC POWER
12122 WH 18 GA
13338 LT BL 18 GA
12120D WH 18 GA
13331 LT BL 18 GA
11086C PK/BK 16 GA
AIR SEAT GRD
ILLUMINATION GRD
ILLUMINATION IGN
AIR SEAT IGN
P27 OPTION CONNECTOR
11088I PK/BK 16 GA.
1212PP WH 18 GA
11068J PK/BK 16 GA
GROUND
IGNITION DROPOUT



Master Chassis w/Lift Control

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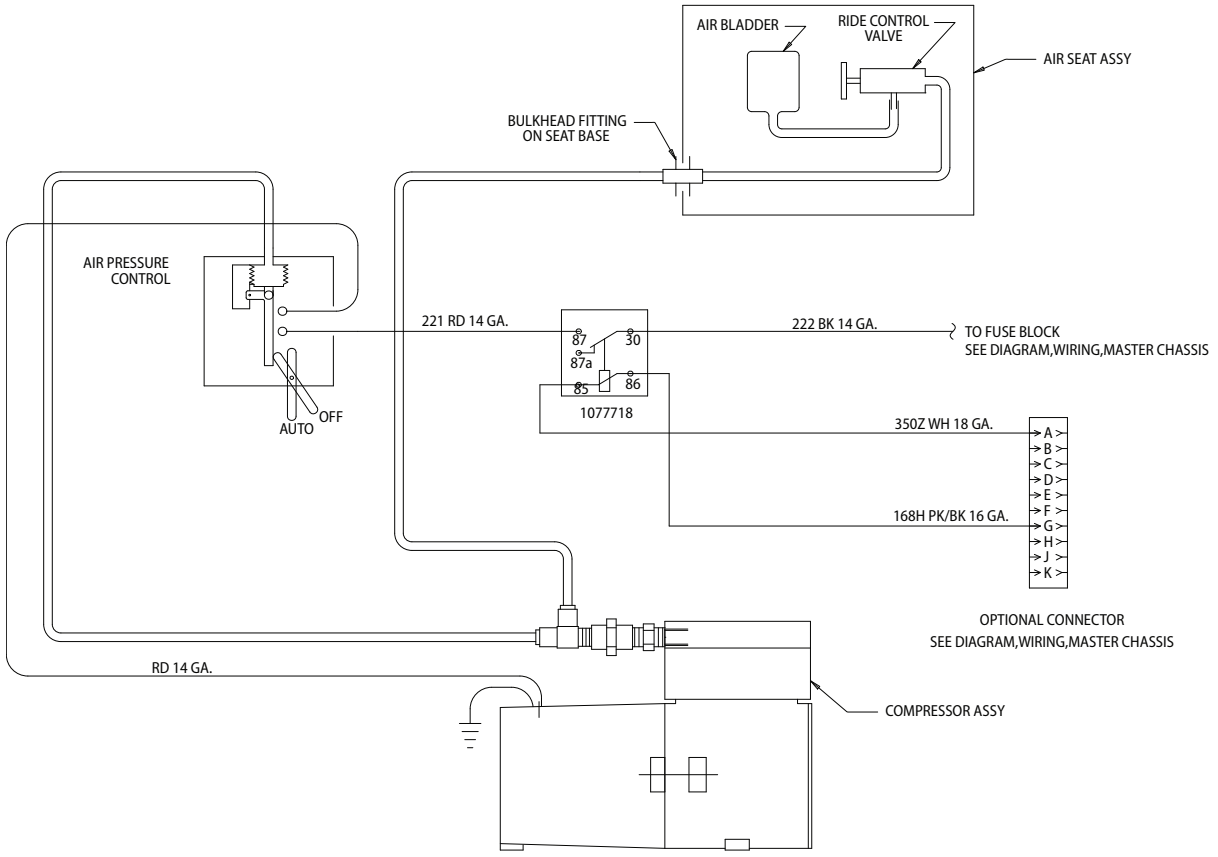
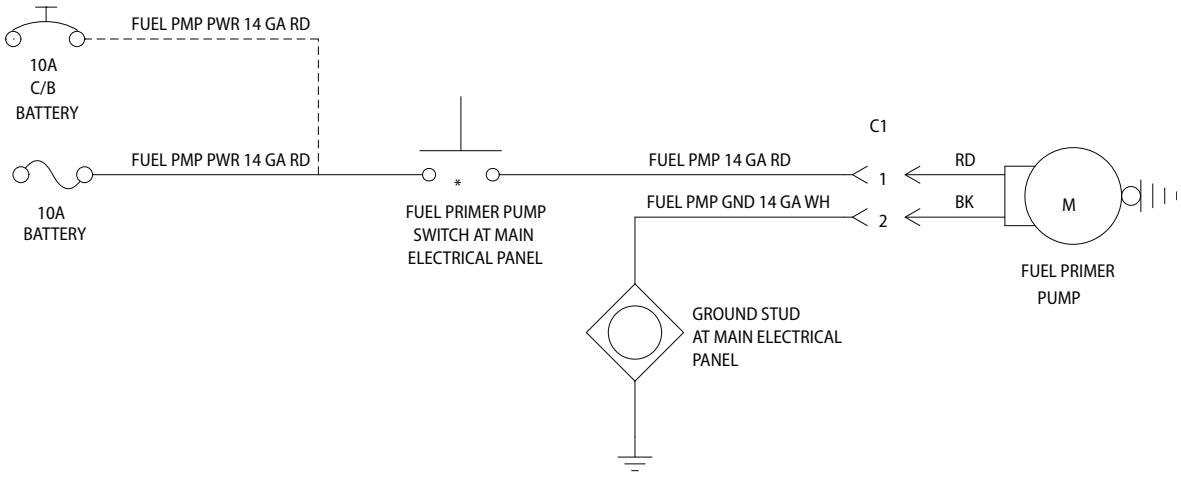


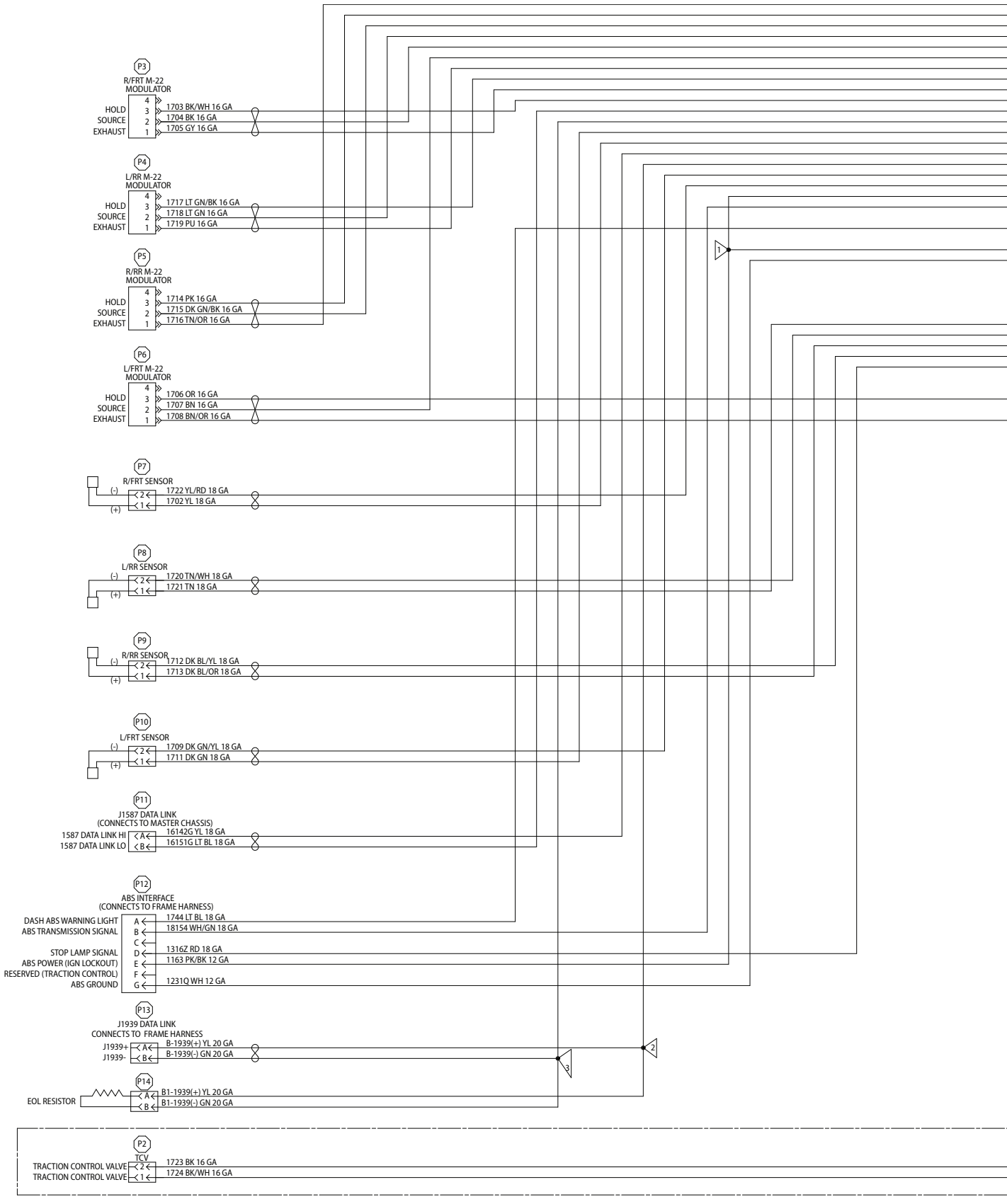
Air Compressor

01701887C



Fuel Pump

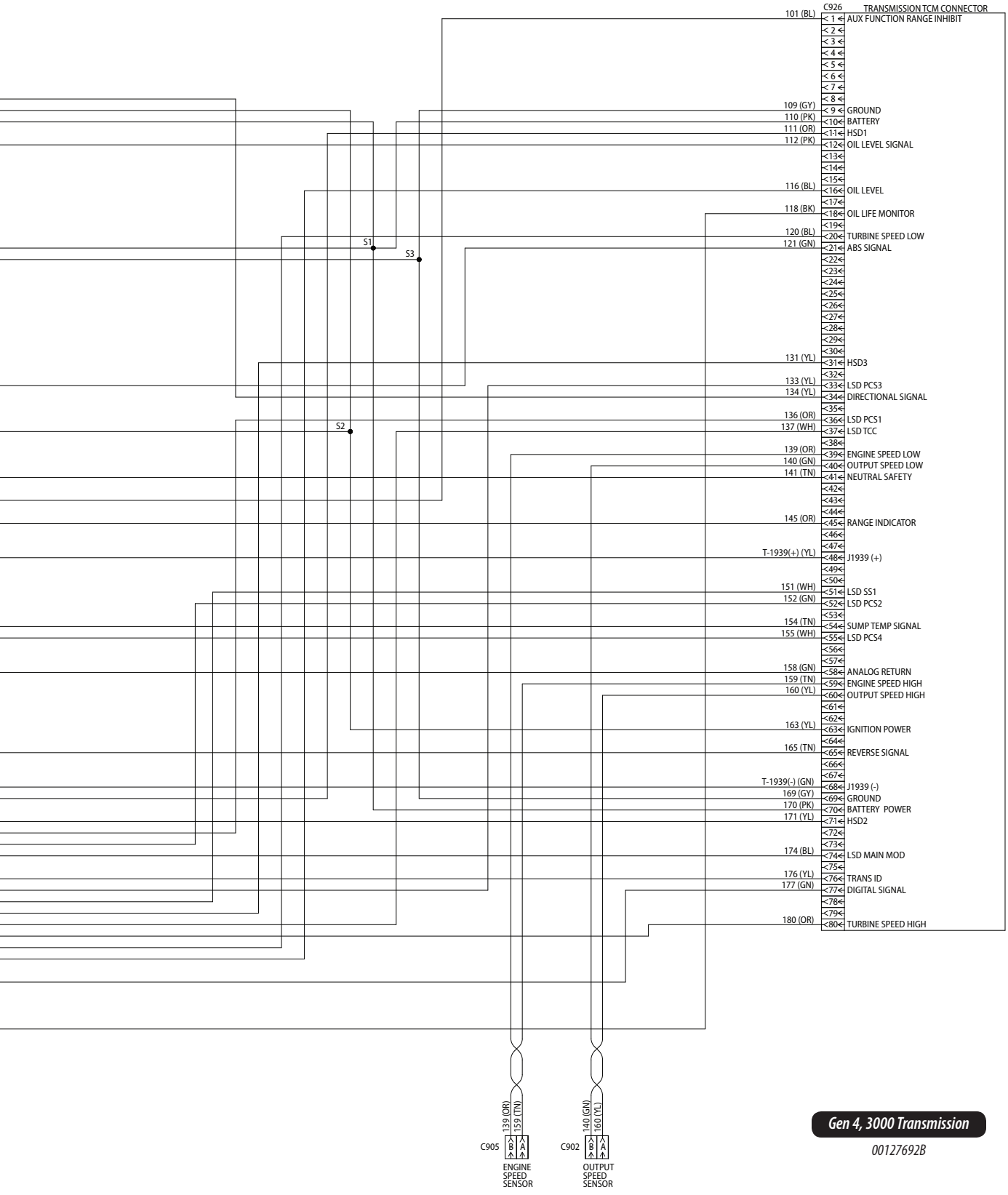
D0125826A


P3
R/FRT M-22 MODULATOR
4
HOLD 3
SOURCE 2
EXHAUST 1
1703 BK/WH 16 GA
1704 BK 16 GA
1705 GY 16 GA
P4
L/RR M-22 MODULATOR
4
HOLD 3
SOURCE 2
EXHAUST 1
1717 LT GN/BK 16 GA
1718 LT GN 16 GA
1719 PU 16 GA
P5
R/RR M-22 MODULATOR
4
HOLD 3
SOURCE 2
EXHAUST 1
1714 PK 16 GA
1715 DK GN/BK 16 GA
1716 TN/OR 16 GA
P6
L/FRT M-22 MODULATOR
4
HOLD 3
SOURCE 2
EXHAUST 1
1706 OR 16 GA
1707 BN 16 GA
1708 BN/OR 16 GA
P7
R/FRT SENSOR
(-) 2
(+) 1
1722 YL/RD 18 GA
1702 YL 18 GA
P8
L/RR SENSOR
(-) 2
(+) 1
1720 TN/WH 18 GA
1721 TN 18 GA
P9
R/RR SENSOR
(-) 2
(+) 1
1712 DK BL/YL 18 GA
1713 DK BL/OR 18 GA
P10
L/FRT SENSOR
(-) 2
(+) 1
1709 DK GN/YL 18 GA
1711 DK GN 18 GA
P11
J1587 DATA LINK
(CONNECTS TO MASTER CHASSIS)
1587 DATA LINK HI A
1587 DATA LINK LO B
16142G YL 18 GA
16151G LT BL 18 GA
P12
ABS INTERFACE
(CONNECTS TO FRAME HARNESS)
DASH ABS WARNING LIGHT A
ABS TRANSMISSION SIGNAL B
C
STOP LAMP SIGNAL D
ABS POWER (IGN LOCKOUT) E
RESERVED (TRACTION CONTROL) F
ABS GROUND G
1744 LT BL 18 GA
18154 WH/GN 18 GA
1316Z RD 18 GA
1163 PK/BK 12 GA
1231Q WH 12 GA
P13
J1939 DATA LINK
CONNECTS TO FRAME HARNESS
J1939+ A
J1939- B
B-1939(+) YL 20 GA
B-1939(-) GN 20 GA
P14
EOL RESISTOR
A
B
B1-1939(+) YL 20 GA
B1-1939(-) GN 20 GA
P2
TCV
TRACTION CONTROL VALVE 2
TRACTION CONTROL VALVE 1
1723 BK 16 GA
1724 BK/WH 16 GA
1
2
3

ABS, Bendix EC-60

00127687B

SHIFT SELECTOR
C932
C6
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939 (+)
T1-1939(+) (YL)
JPR (OR)
JPR (OR)
134 (YL)
DIRECTIONAL SIGNAL
IGNITION
BATTERY POWER
TRANS IGN A (OR)
TRANS BAT A (RD)
J1939 (-)
T1-1939(-) (GN)
ELECTRONIC POWER
C5
BATTERY POWER
BATTERY GROUND
TRANS BAT (PK)
TRANS GND (GY)
VEHICLE/FRAME INTERFACE
C2
RANGE INDICATOR
REVERSE SIGNAL
145 (OR)
165 (TN)
NEUTRAL START
141 (TN)
ABS SIGNAL(-)
121 (GN)
TRANSMISSION IGNITION
TRANS IGN (OR)
TRANSMISSION INPUT/OUTPUT
C7
AUX FUNCTION RANGE INHIBIT
101 (BL)
J1939 DATALINK
C910
CONNECTS TO ENGINE HARN
J1939 (+)
J1939 (-)
T-1939(+) (YL)
T-1939(-) (GN)
J1939 DATALINK
C936
CONNECTS TO MASTER CHASSIS HARN
J1939 (+)
J1939 (-)
T1-1939(+) (YL)
T1-1939(-) (GN)
MAIN TRANSMISSION CONNECTION
C906
HSD1
LSD PCS4
DIGITAL SIGNAL
LSD PCS1
LSD PCS2
HSD2
LSD MAIN MOD
LSD PCS3
LSD SS1
HSD3
LSD TCC
TURBINE SPEED HIGH
TURBINE SPEED LOW
OIL LEVEL
OIL LEVEL SIGNAL
SUMP TEMP SIGNAL
ANALOG RETURN
TRANS ID
111 (OR)
155 (WH)
177 (GN)
136 (OR)
152 (GN)
171 (YL)
174 (BL)
133 (YL)
151 (WH)
131 (YL)
137 (WH)
180 (OR)
120 (BL)
116 (BL)
112 (PK)
118 (BK)
154 (TN)
158 (GN)
176 (YL)



Gen 4, 3000 Transmission

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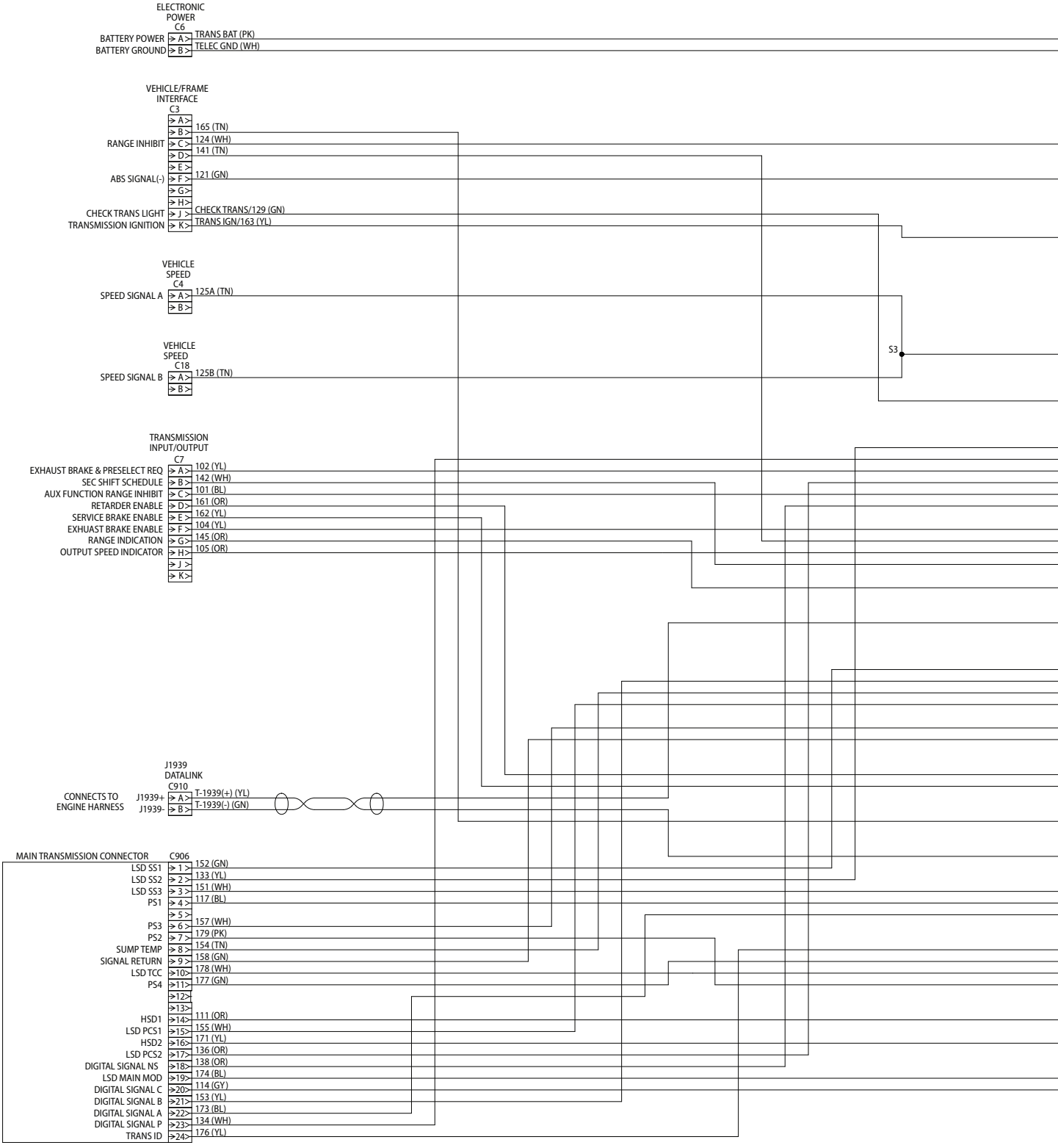
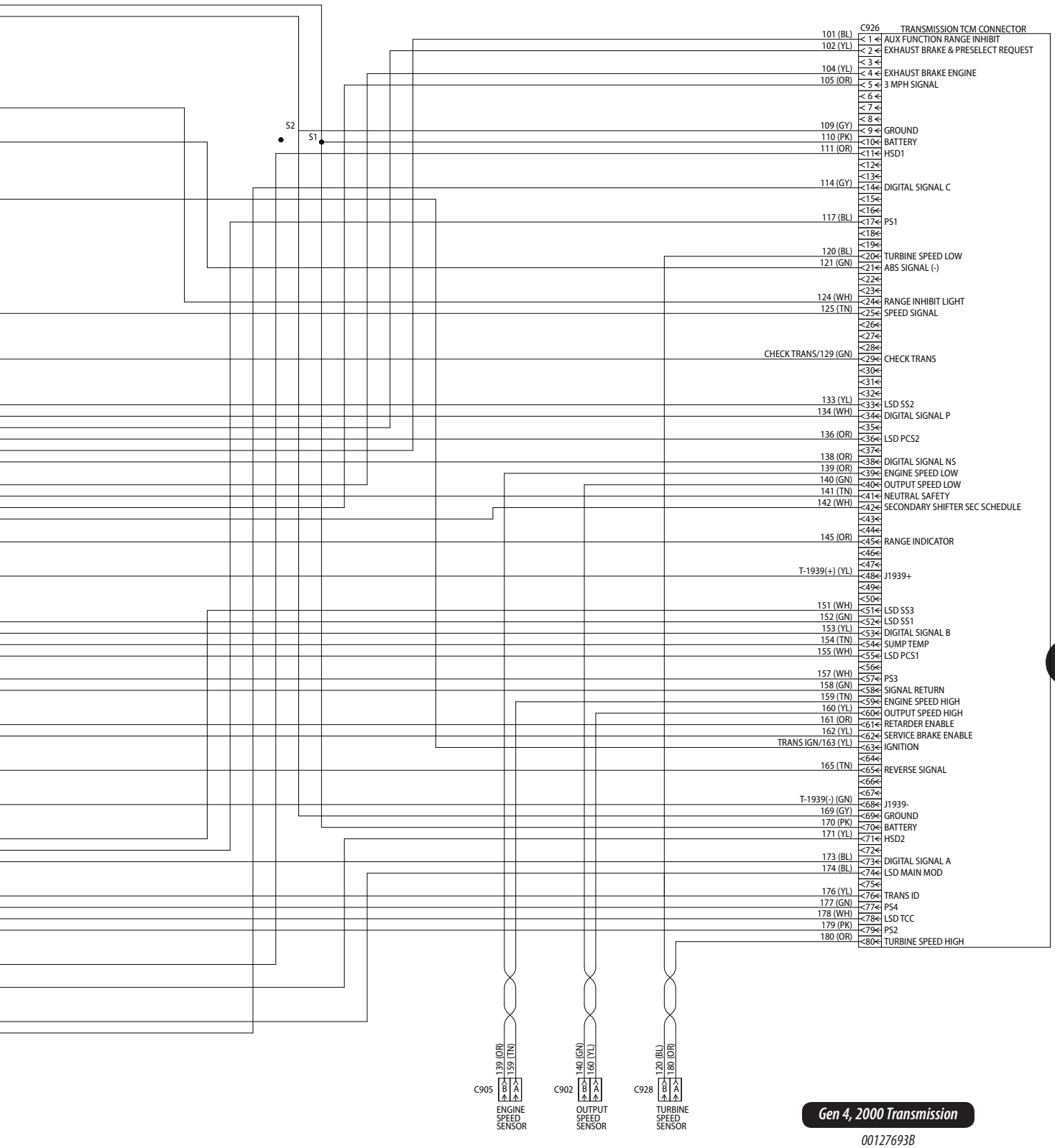

ELECTRONIC POWER
C6
BATTERY POWER
BATTERY GROUND
> A >
> B >
TRANS BAT (PK)
TELEC GND (WH)
VEHICLE/FRAME INTERFACE
C3
RANGE INHIBIT
ABS SIGNAL(-)
CHECK TRANS LIGHT
TRANSMISSION IGNITION
> A >
> B >
> C >
> D >
> E >
> F >
> G >
> H >
> J >
> K >
165 (TN)
124 (WH)
141 (TN)
121 (GN)
CHECK TRANS/129 (GN)
TRANS IGN/163 (YL)
VEHICLE SPEED
C4
SPEED SIGNAL A
125A (TN)
VEHICLE SPEED
C18
SPEED SIGNAL B
125B (TN)
S3
TRANSMISSION INPUT/OUTPUT
C7
EXHAUST BRAKE & PRESELECT REQ
SEC SHIFT SCHEDULE
AUX FUNCTION RANGE INHIBIT
RETARDER ENABLE
SERVICE BRAKE ENABLE
EXHUAST BRAKE ENABLE
RANGE INDICATION
OUTPUT SPEED INDICATOR
102 (YL)
142 (WH)
101 (BL)
161 (OR)
162 (YL)
104 (YL)
145 (OR)
105 (OR)
J1939 DATALINK
C910
CONNECTS TO ENGINE HARNESS
J1939+
J1939-
T-1939(+) (YL)
T-1939(-) (GN)
MAIN TRANSMISSION CONNECTOR
C906
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
>1>
>2>
>3>
>4>
>5>
>6>
>7>
>8>
>9>
>10>
>11>
>12>
>13>
>14>
>15>
>16>
>17>
>18>
>19>
>20>
>21>
>22>
>23>
>24>
152 (GN)
133 (YL)
151 (WH)
117 (BL)
157 (WH)
179 (PK)
154 (TN)
158 (GN)
178 (WH)
177 (GN)
111 (OR)
155 (WH)
171 (YL)
136 (OR)
138 (OR)
174 (BL)
114 (GY)
153 (YL)
173 (BL)
134 (WH)
176 (YL)



Gen 4, 2000 Transmission

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Overview

This section will address those parts of the steering system related to the:

- Steering wheel
- Steering column
- Power steering fluid requirements
- Steering gear (TAS 65)
- Hydraulic steering pump

Appendixes In This Chapter

Appendix 1. TAS Steering Gear (Exerpt). This four page exerpt from TRW's Steering Gear Service Manual includes fluid information, an exploded parts diagram, and torque specifications for the TAS65 steering gear.

Appendix 2. Popped Adjustment. This four page TRW Service Bulletin explains on-vehicle poppet readjustment procedure.

Appendix 3. TRW Steering Maintenance. This TRW publication, entitled *Chart Your Way To Easy Steering,* provides a solid overview of potential steering problems, their diagnosis and correction.

WARNING ***Hydraulic fluid must be handled, stored and disposed of in a manner consistent with all the applicable local, state, and federal guidelines concerning hazardous materials.***

The hydraulic pump for the power steering assist is located on the engine. The configuration of piping from the pump to the steering gear is dependent on whether the bus has hydraulic brakes or an air brake system.

On All Americans equipped with air brakes, the power steering fluid flows from the reservoir to the pump, then to the steering gear, and returns directly to the reservoir. On All Americans equipped with hydraulic brakes, the power steering fluid flows from the reservoir to the pump and then to the power steering gear. The fluid is then directed to the hydraulic brake power assist (booster). From there, the power steering fluid is returned to the reservoir.

Torque from the steering wheel is transmitted through the steering column to the steering gear. The TAS 65 steering gear assists the efforts of the driver.

CAUTION ***The power steering fluid and the brake fluid are not the same. They must be kept separate. Use DOT–3 for the brake system and use Dexron III for the power steering fluid.***

Other oils are acceptable for the power steering system; however, the system must be drained and flushed to use any of these. (See the appropriate TRW Service Manual for a complete list.) Do not mix oils or fluids if you change the fluid.

The steering reservoir on an All American Front Engine (AAFE) can be accessed by opening the left front access panel. The hydraulic brake reservoir is located inside the bus behind the drivers seat and under an access cover.

The steering system and the hydraulic fan drive system on an All American Rear Engine (AARE) share a common hydraulic reservoir. The reservoir is located in the right hand side of the engine compartment

Steering System Maintenance

Before attempting to work on the steering gear, or any portion of the steering system, you must stabilize the vehicle. Read and understand the Warnings and Cautions in the General Maintenance chapter of this manual.

Regularly check the fluid level in the power steering reservoir. Change the fluid and replace the filter at the intervals specified in the Specs & Maintenance chapter. Clean around the reservoir filler cap before removing it. Dirt and other foreign matter can damage the hydraulic system.

Do not bend or straighten any steering component or linkage. Never attempt to weld any broken steering component. Do not use a torch to remove any steering component. Use only original equipment replacement parts.

Never use high pressure or steam to clean the power steering gear while on or off the bus. Doing so can force contaminants inside the gear and lead to malfunction.

Proper alignment of the steering column is important to assure smooth steering. Correct the cause of any free play, rattle, or shimmy immediately to avoid damage to the steering system. Record and report any malfunctions or accidents which may have damaged steering components.

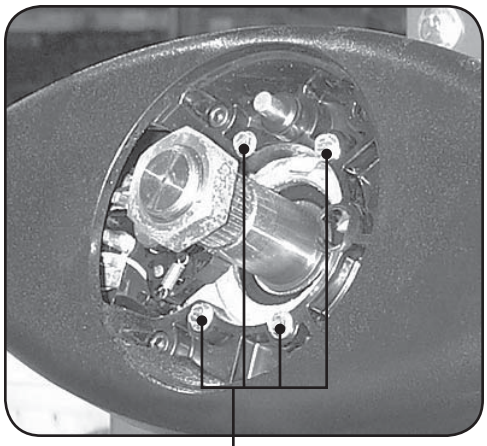
Setting the Steering Poppets

To adjust the steering poppets, refer to Appendix 2 in this chapter.

Refer to the Front Axle Appendix located in the axle chapter of this manual for the following steering related adjustments and lubrication points:

- Axle Stop Adjustment
- Caster and Camber Adjustments
- Toe-in Adjustment
- King-Pin Lubrication
- Te-Rod Lubrication

Steering Wheel & Switches


Steering column housing screws

Steering Wheel & Switch Removal

The hub of the steering column contains the horn connection, the turn signal self cancel mechanism, the dimmer switch for the headlights and the hazard flasher switch. To access these components, it is necessary to remove the steering wheel.

1. Using a small thin tool, such as small screwdriver, carefully remove the horn button from the center of the steering wheel.

2. Remove the large hexnut securing the steering wheel to the steering column.

3. Using a wheel puller of the proper size and shape, remove the steering wheel.

4. Remove the four, ¼-inch, hexhead screws.

5. Using a small thin tool, carefully separate the two pieces of the steering column housing. Be very careful to avoid breaking the wires.

6. Remove the grounding wire from the lower steering column hub.

7. Disconnect the wiring harness from the switch.

8. Remove two screws from the underside of the hub and carefully remove the switch assembly. It is recommended that the whole switch assembly be replaced, not repaired. Contact Blue Bird Parts Sales, or your Blue Bird Dealer, for replacement information.

Steering Wheel & Switch Reinstallation

To replace the switch/wheel assembly, reverse the procedure above.

1. Replace the ¼-inch hexhead screws that secure the switch assembly to the steering column assembly. Torque them to 2–4 ft. lbs. (2.71–5.42 Nm).

2. Connect the wiring harness to the switch.

3. Position the top section of the steering column housing over the lower section and snap into place.

4. Install the four ¼-inch hexhead screws. Torque them to 2–4 ft. lbs. (2.71–5.42 Nm).
   - Ensure the turn indicator lever operates in the normal manner.
   - Check the hazard flasher operation.
   - Check the Headlight dimmer toggle switch for proper operation.

5. Ensure that the front wheels are pointed straight ahead.

6. Ensure the steering wheel is positioned properly.

7. Press the hub of the steering wheel into position over the spline at the end of the steering column shaft.

8. Install the retainer nut at the end of the steering shaft. Torque to 55–65 ft. lbs. (75.57–88.13 Nm). If the threaded end of the steering shaft is not flush with the nut; remove the nut, clean the threads of the nut and the shaft. Then apply 3 drops of Loctite™ (242 blue) or equivalent, and install and torque the nut.

Steering Gear

The TAS 65 is an integral hydraulic power steering unit. The steering gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder. The control valve senses steering requirement from the driver and directs oil flow to the appropriate cylinder cavity at the proper flow rate thus providing a smooth power assist steering.

The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 4 gpm, Minimum flow rate is 2.6 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required by the gear. The pressure of the hydraulic fluid is used to overcome the resistance in the system. The higher the pressure, the more work it can perform. (Maximum operating pressure is 2,175 psi.)

The steering wheel is connected to the steering gear input shaft. The input shaft is connected to a worm shaft. When the driver turns the steering wheel, the input shaft and worm shaft rotate. The worm shaft is in turn connected to a rack piston through the recirculating ball mechanism. This rotational movement moves the rack piston axially in the gear housing cylinder bore. The rack piston turns the sector shaft, which is connected by linkage to the wheels on the front axle.

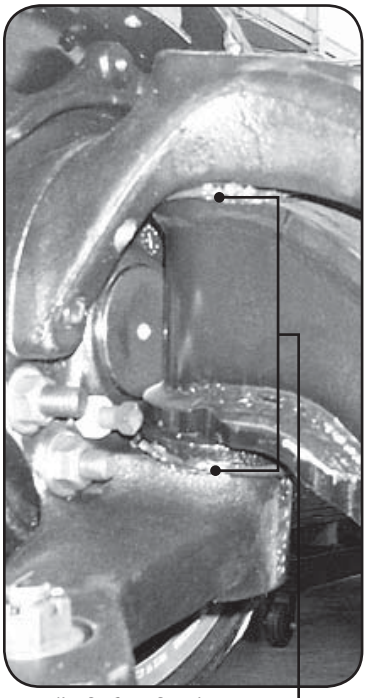
As resistance is encountered in the steering effort, pressure in the steering hydraulic system will increase proportionally to assist the movement of the rack piston, thus reducing the effort needed to steer the bus. As the input shaft is turned, the control valve spool mounted on the torsion shaft (the torsion shaft connects the input shaft to the worm shaft) shifts and redirects oil flow to either side of the rack piston. A relief valve, mounted on the valve housing, limits maximum supply pressure to protect the power steering system. This is the primary pressure protection for the steering system. (A secondary pressure relief valve is located in the hydraulic pump assembly on All American Front Engine units or in the hydraulic fan drive control valve on All American Rear Engine.)

Objectionable kickback is prevented due to the geometry of the steering gear. If the wheels receive a shock load, it is transmitted back through the sector shaft, rack piston, and worm gears. This load is neutralized by the control valve, which sends oil flow to the correct side of the rack piston to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel and driver.

The steering gear is equipped with two poppet valves, one on each end of the rack piston. The poppet valves are set specifically to the turning radius of each bus after the axle stop adjustment has been made. When the steering wheels are turned and approach the axle stop, one poppet valve (depending on the direction of turn) trips. The tripped poppet valve opens, allowing oil flow to bypass the piston, which reduces pressure in the gear and helps reduce heat buildup in the hydraulic system. At the same time, the valves also reduce forces on the steering linkage.

Careful preliminary checks should be done to identify a steering problem and its symptoms before deciding to tear down the steering gear. In most cases, the steering gear should be the last component suspected as cause of a steering problem.

Refer to Appendix 1, 2, and 3 in this chapter for detailed step by step troubleshooting procedures.



King Pin Grease Purge Locations

Steering Pump, Front Engine All American

The hydraulic steering pump on the Blue Bird All American Front Engine is a positive displacement pump with integrated pressure relief valve and a flow regulator valve.

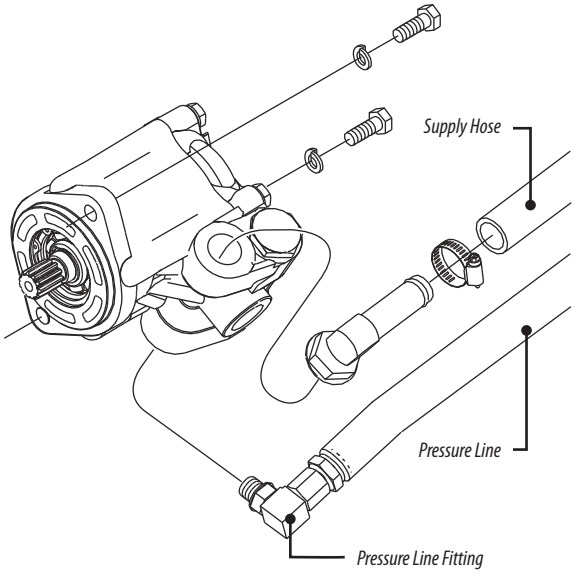
When troubleshooting, it is important to remember to always do the simple steps first. Look for obvious signs of leaking, component wear or damage, and hose problems, before removing the power steering pump. Special attention should be given to the supply hose for signs of clasping or routing issues creating kinks in the hose that could restrict oil flow to the pump.

Using a flow meter, determine whether the pump is providing the necessary flow. The steering pump should provide a flow of 4 (minimum 2.6) gallons per minute (GPM). It is recommended that you use a Power Steering System Analyzer (PSSA) to assist in the diagnosis of steering system problems.

For details on troubleshooting the steering system, see **Appendix 3** in this chapter.

Steering Pump Removal (All American With Air Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.
2. Remove the supply hose (17).
3. Remove the pressure line (16) from the fitting (18) at the output port of the pump.
4. Secure the pressure line safely out of the way.
5. Remove two M10 capscrews from the hydraulic pump mounting flange.
6. Remove and discard the gasket.



Steering Pump Reinstallation (All American With Air Brakes)

Installation is accomplished in the reverse order of the removal instructions. Always install a new hydraulic pump gasket. Also install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (71.86–78.64 Nm).

Ensure the system is full of fluid before starting the engine. After filling the reservoir, start and run the engine at idle for 10 seconds then switch the ignition off, refill the reservoir and run the engine for another 20 seconds, repeat this process until the reservoir maintains a full oil level. With the front wheels off the floor (refer to proper front axle jacking procedures , lift by the axle not the wheels, in the front axle section of this manual) start the engine and turn the steering wheel one direction and then the other direction a couple of times; then stop the engine and refill the reservoir. Perform this cycle until the reservoir maintains a full oil level.

Test drive the bus and let the power steering fluid warm to operating temperature; then check the fluid level again. Check for leaks in the system.

Steering Pump Removal (All American With Hydraulic Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.

2. Remove the supply hose.

3. Remove the pressure line from the fitting at the output port of the pump.

4. Secure the pressure line safely out of the way.

5. Remove two ⅜ Grade 8 capscrews from the hydraulic pump mounting flange.

6. Remove and discard the o-ring.

Steering Pump Reinstallation (All American With Hydraulic Brakes)
Install the pump in the reverse order of the removal. Ensure that a new o-ring is installed. Install a new split ring lock washer and torque the mounting capscrews to 29–33 ft. lbs. (33.32–44.74 Nm).

Steering Pump, Rear Engine All American

Refer to the Hydraulic Fan Drive section in the Cooling system chapter of this manual.

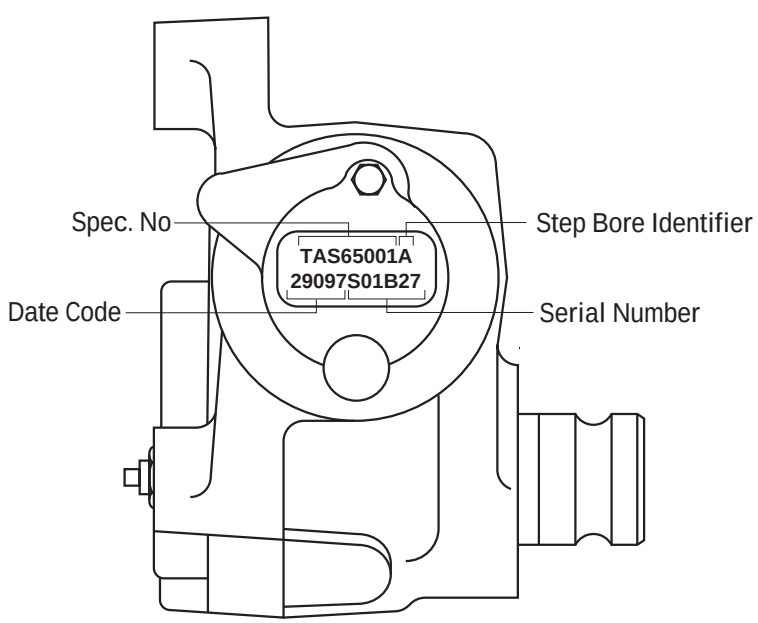
Approved Hydraulic Fluids

Automatic Transmission Fluid Dexron II
Automatic Transmission Fluid Type "E" or "F"
Chevron 10W-40
Chevron Custom 10W-40 Motor Oil
Chevron Torque 5 Fluid
Exxon Nuto H32 Hydraulic Fluid
Fleetrite PSF (Can #990625C2)
Ford Spec. M2C138CJ
Mack EO-K2 Engine Oil
Mobil ATF 210
Mobil Super 10W-40 Motor Oil
Premium Blue 2000 - SAE 15W-40
*Shell Rotella T30W
*Shell Rotella T SAE 30
Texaco 10W-40
Texaco TL-1833 Power Steering Fluid
Union 10W-40
Union 15W-40
Unocal Guardol 15W-40 Motor Oil

The steering system should be kept filled with one of the above fluids. Fluids marked with an asterisk (*) have not been approved for use with TRW's pump.

⚠ WARNING **Completely flush the steering system with one of the recommended fluids above only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

Specification Numbers



The steering gear specification number and date code are stamped on a machined surface opposite the input shaft of every TAS gear. Newer gears include a serial number.

An example date code would be 29097; this means the gear was built on the 290th day of 1997.

An "A" included at the end of the specification number indicates a step bore housing.

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Torque Chart

Part Name	Item #	Torque Range Dry	Torque Range Lubricated
Auxiliary cylinder plug	54	25-35 lbf•ft (34-48 N•m)	
Ball return guide cap/strap bolts	31	14-22 lbf•ft (19-29 N•m)	
Bearing adjuster	17		11-15 lbf•ft (15-20 N•m)*
Locknut	18		101-122 lbf•ft (137-165 N•m)**
Manual bleed screw	50	40-50 lbf•in. (3.1-3.7 N•m)	
Plug, auto bleed	51	38-58 lbf•ft (52-79 N•m)	
Poppet sleeve assembly	22	16-20 lbf•ft (22-27 N•m)	
Poppet sealing nut, service	60	33-37 lbf•ft (45-50 N•m)	
Poppet fixed stop screw	52	38-42 lbf•ft (52-57 N•m)	
Poppet fixed stop screw	52A	38-58 lbf•ft (52-79 N•m)	
Relief valve cap	56	25-35 lbf•ft (34-48 N•m)	
Sector shaft adjusting screw jam nut	47	40-45 lbf•ft (54-61 N•m)	
Side cover bolts (TAS40)	48		108-128 lbf•ft (147-174 N•m)
Side cover bolts (TAS55, 65, 85)	48		160-180 lbf•ft (217-244 N•m)
Valve housing bolts (TAS40, 55, 65)	1		75-85 lbf•ft (102-115 N•m)
Valve housing bolts (TAS85)	1		108-128 lbf•ft (147-174 N•m)

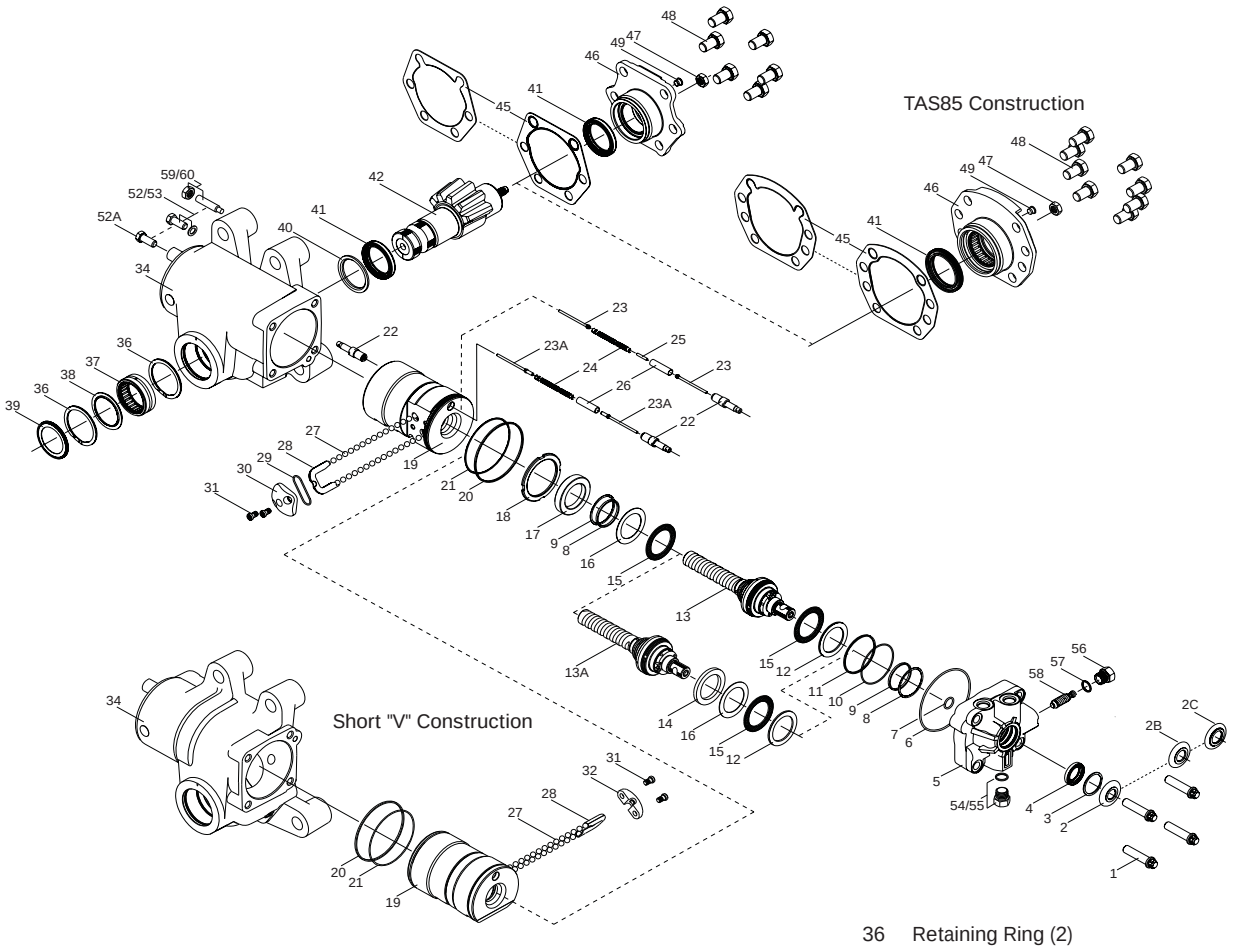
Item numbers referenced are shown on the exploded views, pages 13 and 15.

* After tightening to this torque value, the adjuster must be backed off ¼ to ½ of a turn as described in step 22 on page 61.

** Torque value indicated is using recommended tools.

Special tools can be purchased through:
SPX Corporation
Kent-Moore Tool Group
28635 Mound Road
Warren, MI 48092
1-800-328-6657

TAS Series Exploded View -- Standard



Item	Description
1	Bolts (4-Valve Housing)
*2	Dirt and Water Seal 13/16" Serr.
*2B	Dirt and Water Seal 7/8" Serr.
*2C	Dirt and Water Seal 1" Serr.
*3	Retaining Ring
*4	Seal (Input Shaft)
5	Valve Housing
*6	Seal Ring (Valve Housing)
*7	Seal Ring (Valve Housing)
*8	Seal Ring (2)
*9	O-ring (2)
*10	Seal Ring
*11	O-ring (Valve Housing)
12	Thrust Washer (Thick)
13	Input Shaft, Valve, Worm Assy.
13A	Input Sh., Valve, Worm Assy. (Alt.)
14	Spacer Sleeve (Alt.)
15	Thrust Bearing (1 or 2)
16	Thrust Washer (Thin)
17	Bearing Adjuster
*18	Adjuster Locknut
19	Rack Piston
*20	Teflon Seal Ring
*21	O-ring (Back up; Rack Piston)
22	Poppet Seat and Sleeve Assy. (2)
23	Poppet (2)
24	Poppet Spring
25	Spacer Rod
26	Push Tube
27	Balls
28	Ball Return Guide Halves (2)
*29	Seal (Cap)
30	Ball Return Guide Cap
*31	Torx Screws (2-Cap/Strap)
*32	Ball Return Guide Strap
34	Housing
35	Grease Fitting
36	Retaining Ring (2)
37	Roller Bearing
*38	Dirt Seal
*39	Dirt and Water Seal (Trunnion)
40	Washer (Spacer)
*41	Seal (2-Output)
42	Sector Shaft
43	Adjusting Screw (Sector Shaft)
44	Retainer (Adjusting Screw)
*45	Gasket (Side Cover)
46	Side Cover Assembly
47	Jam Nut
48	Special Bolts (6 or 8-Side Cover)
*49	Vent Plug (Side Cover)
50	Bleed Screw (Manual)
51	Plug (Auto Bleed)
52	Fixed Stop Screw (Poppet)
52A	Fixed Stop Screw (Poppet-Alt)
53	Washer (Stop Screw)
54	Auxiliary Port Plug (2)
*55	O-ring (2-Aux. Port Plug)
56	Relief Valve Cap
*57	O-ring (Relief Valve)
58	Relief Valve (2 piece)
59	Service Poppet Adjusting Screw
60	Service Sealing Jam Nut

*These items are included in complete seal kits along with 406038 lubricant and a service bulletin.

Service Parts List - Standard

Common Parts

Item	Description	Part Number
1	Bolts (4-Valve Housing)	020251
2	Dirt and Water Seal 13/16" Serr.	478044
2B	Dirt and Water Seal 7/8" Serr.	478060
2C	Dirt and Water Seal 1" Ser	478050
3	Retaining Ring	401637
4	Seal (Input Shaft) (High Temp)	478076
7	Seal Ring (Valve Housing)	032823
8	Seal Ring (2)	029123
9	O-ring (2) (High Temp)	032200-158
10	Seal Ring	029116
11	O-ring (Valve Housing) (High Temp)	032200-152
12	Thrust Washer (Thick)	400143
15	Thrust Bearing (2)	070027
16	Thrust Washer (Thin)	400144
17	Bearing Adjuster	400149
18	Adjuster Locknut	027007
27	Balls	213684-X1
29	Seal (Cap)	478042
30	Ball Return Guide Cap	400161
31	Torx Screws (2-Cap/Strap)	020228
32	Ball Return Guide Strap	400167
35	Grease Fitting	037032
43	Adjusting Screw (Sector Shaft)	021200
44	Retainer (Adjusting Screw)	062005
47	Jam Nut	025150
49	Vent Plug (Side Cover)	036201
50	Bleed Screw (Manual)	213705
51	Plug (Auto Bleed)	021397
52A	Fixed stop screw	021426
54	Auxiliary Port Plug (2)	415437-A1
55	O-ring (2-Aux. Port Plug)	032229
57	O-ring (Relief Valve)	032200-153
59	Service Poppet Adjusting Screw	021407
60	Service Sealing Jam Nut	025119

Parts Vary by Specification*

Item	Description
5	Valve Housing
13	Input Shaft, Valve, Worm Assy.
13A	Input Shaft, Valve, Worm Assy. (Alt.)**
14	Spacer Sleeve (Alt.)**
19	Rack Piston
34	Housing
42	Sector Shaft
46	Side Cover Assembly
56	Relief Valve Cap
58	Relief Valve (2 piece)

*Contact Service/Sales for part numbers
**Applicable to TAS65 gears only

Kits

Items	Description	Part Number
54 & 55	Port Plug & O-ring	415437-A1
56 & 57	Relief Valve Cap & O-ring	411061-A1
59 & 60	Adj. Screw & Jam Nut	021407-X1
2, 2B, 2C, 3, 4	Input Shaft Seal Kit	TAS000001
	TAS40 Seal Kit	TAS400003
	TAS55 Seal Kit	TAS550004
	TAS65 Seal Kit	TAS650012
	TAS85 Seal Kit	TAS850003 or 4

Parts Vary by Gear Size

Item	Description	TAS40	TAS55	TAS65	TAS85
6	Seal Ring (Valve Housing)	032829	032829	032616	032834
20	Teflon Seal Ring	032828	032830	032590	032547
21	O-ring (Back up; Rack Piston)	032827	032831	032615	032556
22	Poppet Seat and Sleeve Assy. (2)	409118-A2	409118-A2	409118-A2	409118-A6
23	Poppet (2-old design)	040210	040210	040210	040217
23A	Poppet (2-new design)	040248	040248	040248	040249
24	Poppet Spring	401662	401662	401662	401684
25	Spacer Rod	040209	040209	040209	040218
26	Push Tube	080154	080154	080154	080158
28	Ball Return Guide Halves (2) R.H.	400158	400160	400156	400162
	L.H.	400159	400165	400157	400163
36	Retaining Ring (2)	401674	401650	401650	401685
37	Roller Bearing	070030	071032	071033	072004
38	Dirt Seal	478052	478041	478041	478057
39	Dirt and Water Seal (Trunnion)	478053	478045	478045	478059
40	Washer (Spacer)	028527	028519	028519	028534
41	Seal (2-Output)	478051	478040	478040	478084
45	Gasket (Side Cover)	HFB529000	HFB649000	HFB649000	TAS859000
48	Special Bolts (6 or 8-Side Cover)	021277	021434	021434	021434

TRW Automotive
Steering & Suspension Systems

Service Bulletin #TAS-101

On-Vehicle Poppet Readjustment for TAS Gears

Revised January, 1993
Electronic Version April, 1998

This TRW Commercial Steering Division service bulletin has been written to help you repair commercial vehicles more efficiently. This bulletin should not replace your manuals; you should use them together. These materials are intended for use by properly trained, professional mechanics, NOT "Do-it-yourselfers". You should not try to diagnose or repair steering problems unless you have been trained, and have the right equipment, tools and know-how to perform the work correctly and safely.

What are poppets?

Poppets are pressure unloading valves set to trip just before full turn is reached in each direction. When this procedure is completed correctly, system pressure will be reduced before the axle stop screw contacts the axle stop in both directions.

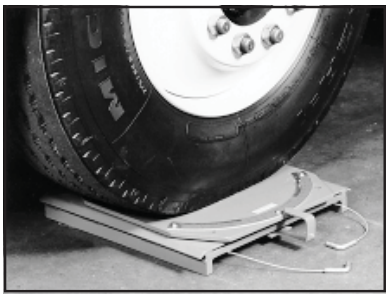
To determine if the poppets require readjustment or if they are performing properly, install a Power Steering System Analyzer (PSSA) between the power steering pump and the steering gear. If poppet readjustment is necessary, you can leave the PSSA in the system to verify that the following procedure is completed properly.

911

Why might poppets need to be readjusted?

- Changing to larger tires
- Reduced vehicle wheelcut
- Pitman arm mistimed, condition corrected
- Steering gear being installed on a different truck
- Steer axle stop bolt(s) were bent or broken
- Steer axle u-bolt(s) were bent or broken

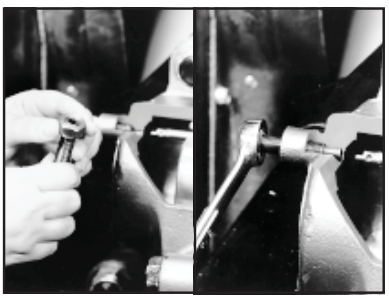
NOTE This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to internally reset the poppets using the procedure described in the TAS Service Manual.



Set axle stops, warm-up system

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

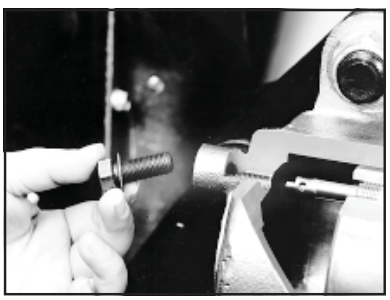
   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.



Assemble adjusting screw into nut

2. If a new poppet adjusting screw and nut are being used, turn the screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

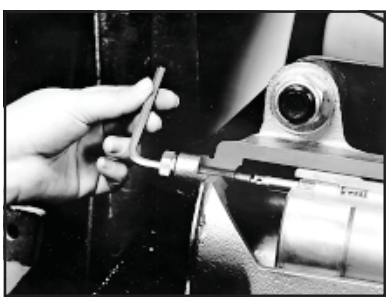
   Your steering gear will have either a fixed stop bolt or an adjusting screw. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.



Remove poppet stop bolt

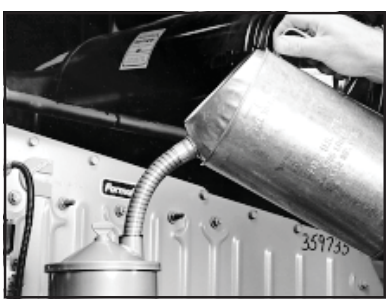
3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of housing.

   If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.



Turn adjusting screw assembly into housing

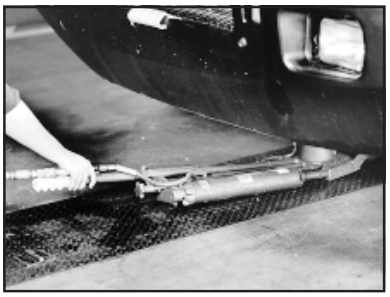
4. Turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a 7/32" allen wrench. Tighten the sealing nut against the housing.



Refill reservoir

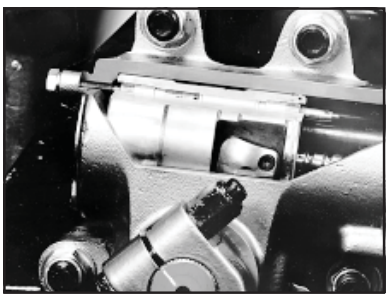
5. Refill system reservoir with approved hydraulic fluid.

⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**



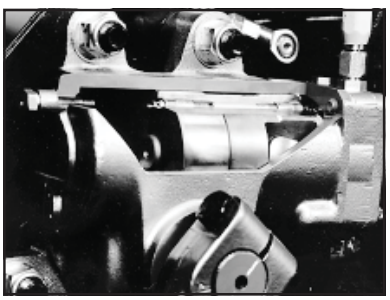
Jack up vehicle

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.



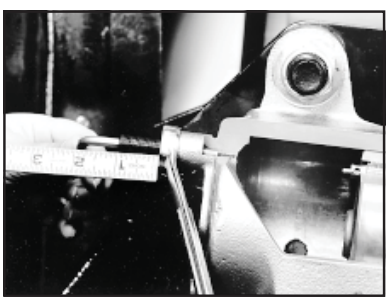
Push upper poppet out to prepare it for setting

7. **a)** Start the engine and let it run at idle speed.
b) Note which output shaft timing mark is nearest the housing piston bore.
c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.
d) Pull hard on the steering wheel (put 30 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.



Set upper poppet

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.
b) Pull hard on the steering wheel (put 30 lbs. rim pull on a 20" dia. steering wheel).
c) Release the steering wheel and shut off the engine.



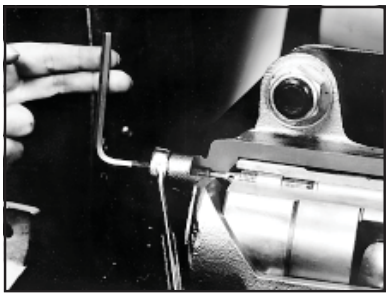
Back out adjusting screw

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut. Tighten the sealing nut against the housing.

⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

Set lower poppet

10. **a)** Start the engine and let it idle.
b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.
c) Hold the steering wheel in this position (with 30 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 11.



Position adjusting screw

11. **a)** With steering wheel held at full turn, loosen the jam nut and hold it in place with a wrench.
    b) Turn the adjusting screw in (clockwise) using finger- pressure only (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.
    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 lbf·ft.**

The procedure is complete

12. The poppets have now been completely reset. Lower the vehicle . Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1/16" for proper thread engagement.**

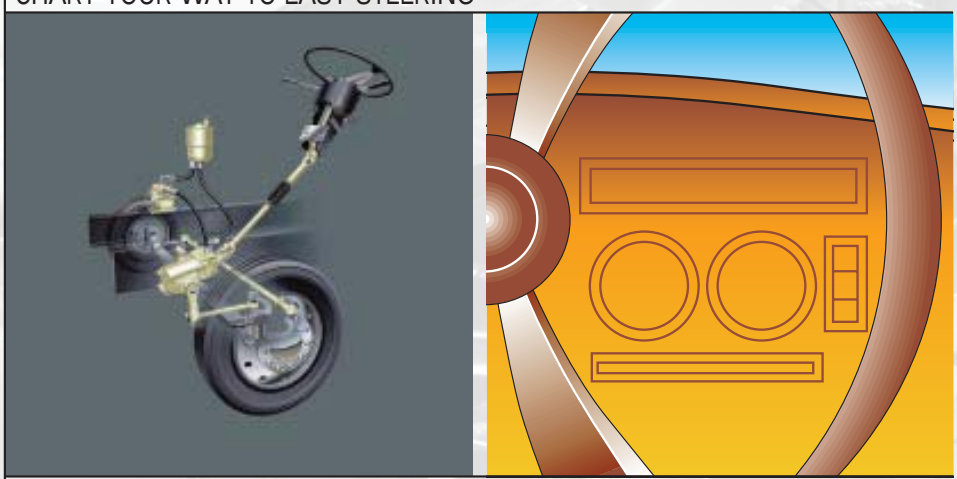
NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

TRW Commercial Steering Division
P.O. Box 60
Lafayette, IN 47902
Phone: 765.423.5377
Fax: 765.429.1868

TRW Automotive
Commercial Steering Systems

Steering Diagnostics Service Manual

CHART YOUR WAY TO EASY STEERING



⚠ WARNING	**A warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Notice

This guide was prepared for the purpose of providing general advice concerning the diagnosis and correction of commercial vehicle steering related problems. This guide is intended for the use of properly trained, professional mechanics, NOT "Do-it-Yourselfers". Also, this guide should be used in conjunction with service manuals provided by both the vehicle and component manufacturers. Diagnosis and correction of commercial vehicle steering related problems should only be handled by properly trained, professional mechanics who have the proper equipment, tools, instructions and know-how to perform the work properly and safely.

Power Steering System Analyzer (PSSA) Gauge

Some of the tests in this manual require the use of a PSSA. This device is a combination flow meter, shut-off valve, and pressure gauge. This tool will allow you to measure flow and pressure, and provide a load on the pump through the hydraulic lines of the steering system. This tool is required to correctly analyze a steering system. TRW recommends that you **DO NOT BEGIN TROUBLESHOOTING A STEERING SYSTEM WITHOUT THE USE OF A PSSA.** If you are not sure how to use a PSSA, you may refer to the video available through our website at: *www.trucksteering.com*. This video compliments the tests in this book which require the use of the PSSA.

⚠ **WARNING**

Throughout this troubleshooting guide, test procedures are recommended to help locate the cause of each complaint. While performing these tests, TRW advises that you TAKE NECESSARY PRECAUTIONS when working with internal vehicle components and hot hydraulic fluids.

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Section 1 Preface

Introduction 3

- Understanding the Complaint
- Reading the Flow Charts
- Warranty

Definitions 4-5

- Hard Steering
- Reduced Wheelcut
- Steering Wheel Kick
- Binding, Darting, and Oversteer
- Directional Pull
- Road Wander/Loose Steering
- Non-Recovery
- Shimmy
- Noise
- External Leakage

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Introduction

Understanding the Complaint

Steering systems for heavy duty trucks are made up of many components from the steering wheel to the road wheel. The purpose of the steering system is to give the driver directional control of the vehicle.

When a driver feels the steering control over his/her vehicle is not like it should be, it is up to you to determine if there is a problem, and if so, figure out what is causing it. It is always easier to fix something if you really understand the complaint. Some ways you could do this are:

- Talk to the driver and ask a lot of questions like "what, when, where, and how"
- Make sure you can feel or see the problem. Have the driver show you exactly what he/she means.
- Walk around the truck, looking for anything that may be an obvious cause of the problem.

To make your job easier and faster this manual has both the flow charts and test procedures/comments, each in their own section. Once you have a good understanding of what the complaint is, choose the flow chart that best matches the symptoms described to you. Because there are different ways to say the same thing, we have provided our definitions of the 10 most common complaints in this book. Use these to determine which section of the manual would be helpful to begin diagnosing the steering system.

Reading the flow charts:

Start the chart at the **BEGIN** box. Follow the lines to the next box answer the question or perform the test to verify the cause of the complaint, then proceed to the next step. These boxes are arranged in order of likelihood of being the cause of the driver's complaint. **It is important to complete the tests, in order, and follow the flow of the chart**. Locate correct test number in the TEST PROCEDURES section, and follow the test procedure. When you are done with the test, note the results and correct the root cause. If condition still exists, keep going through the chart (if necessary, to correct the problem). The results of some tests will need to be recorded. Use the TEST RESULTS section to record these values.

If you identify a problem through a test procedure it is important that you retest the vehicle to make sure the condition has been corrected.

Warranty

If you have identified that a steering component on your vehicle needs to be replaced, this does not always mean it is warrantable. Please read your manufacturer's warranty carefully before submitting a steering component for warranty consideration.

Definitions

1. Hard Steering

Hard Steering is when steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs at the rim of the steering wheel). Steering is still possible, but there is not enough power assist.

Common phrases used:

- Won't turn
- Locks-up
- Shuts-down
- Turns hard
- Hangs-up
- No assist
- Won't turn unless moving

2. Reduced Wheelcut

Common phrases used:

- Too great of turning radius required
- Wheelcut restricted
- Not enough turns lock to lock

3. Steering Wheel Kick

Steering Wheel Kick is when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly.

Common phrases used:

- Kickback
- Backlash
- Bump steer

4. Binding, Darting and Oversteer

Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe. Darting and oversteer are words that mean the driver suddenly gets more turning than he/she wants.

5. Directional Pull

Common phrases used:

- Steering pulls to the right (or left)
- Truck pulls to the right (or left)
- A constant force is required to keep the truck going straight

Definitions

6. Road Wander/Loose Steering

Common phrases used:

- Lash in steering
- Lost motion in steering
- Continual corrections are needed at the steering wheel to keep the vehicle from wandering

7. Non-Recovery

Common phrases used:

- Wheels don't return to straight ahead

8. Shimmy

A severe Shimmy condition can be felt at the steering wheel. Typically once something triggers a Shimmy condition to occur it is sustained until the driver does something (such as slow down) to dampen out the condition.

Common phrases used:

- Shake at steering wheel

9. Noise

Common phrases used:

- Steering is noisy
- Clicking or clunking sound is heard when steering

10. External Leakage

Common phrases used:

- Loss of steering fluid
- Continual adding of fluid in reservoir required

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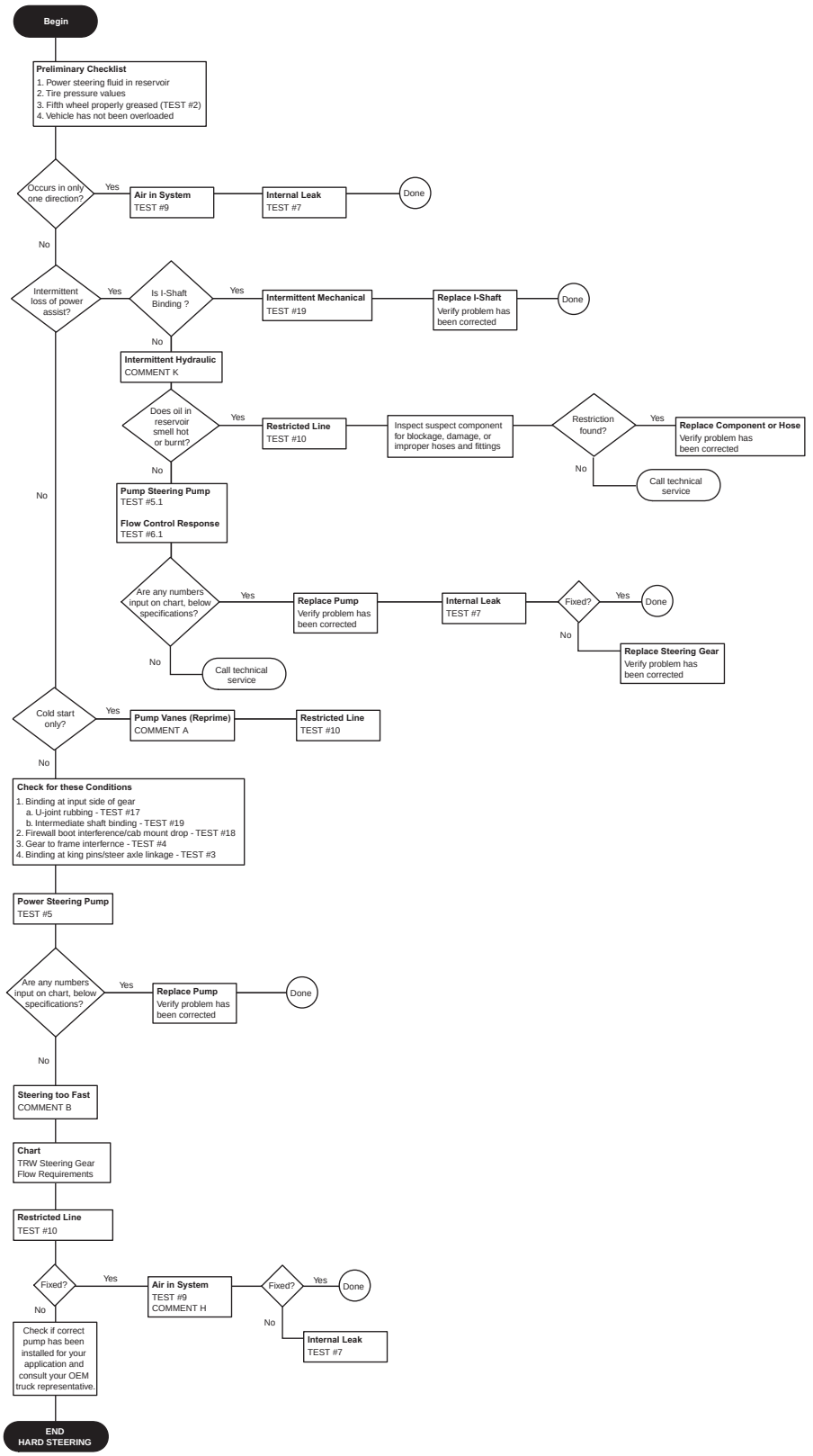
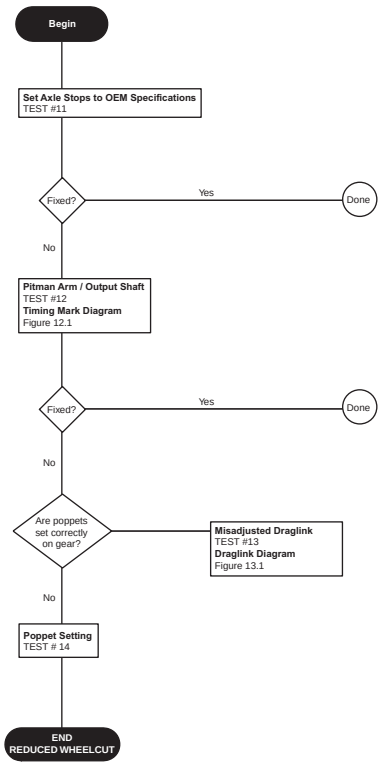
Section 2 Flow Chart Diagrams

Hard Steering 8
Reduced Wheelcut 9
Steering Wheel Kick 10
Binding, Darting, and Oversteer 11
Directional Pull 12
Road Wander/Loose Steering 13
Non-Recovery 14
Shimmy 15
Noise 16
External Leakage 17

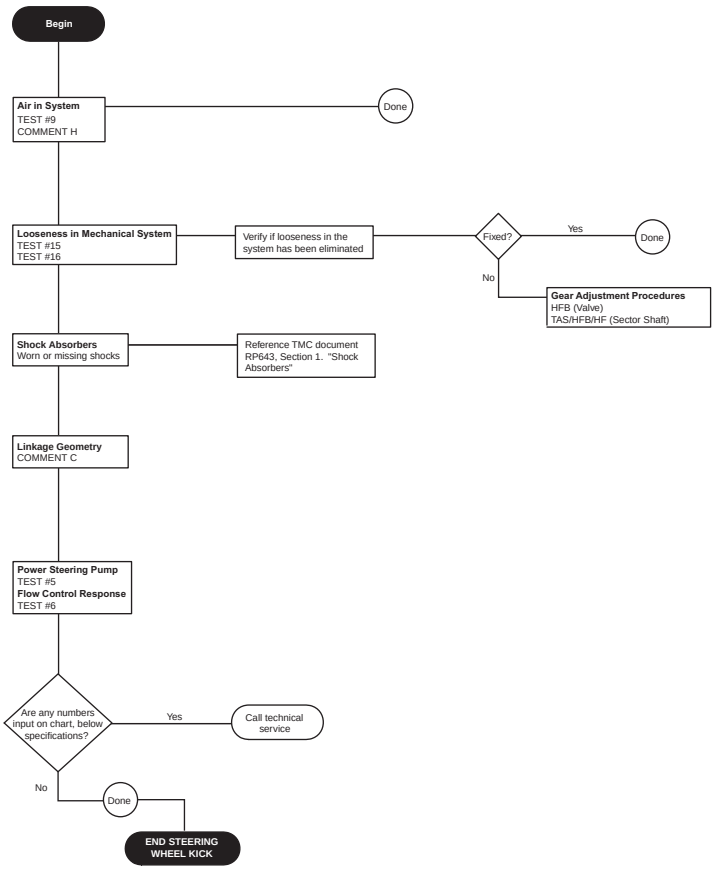
Hard Steering



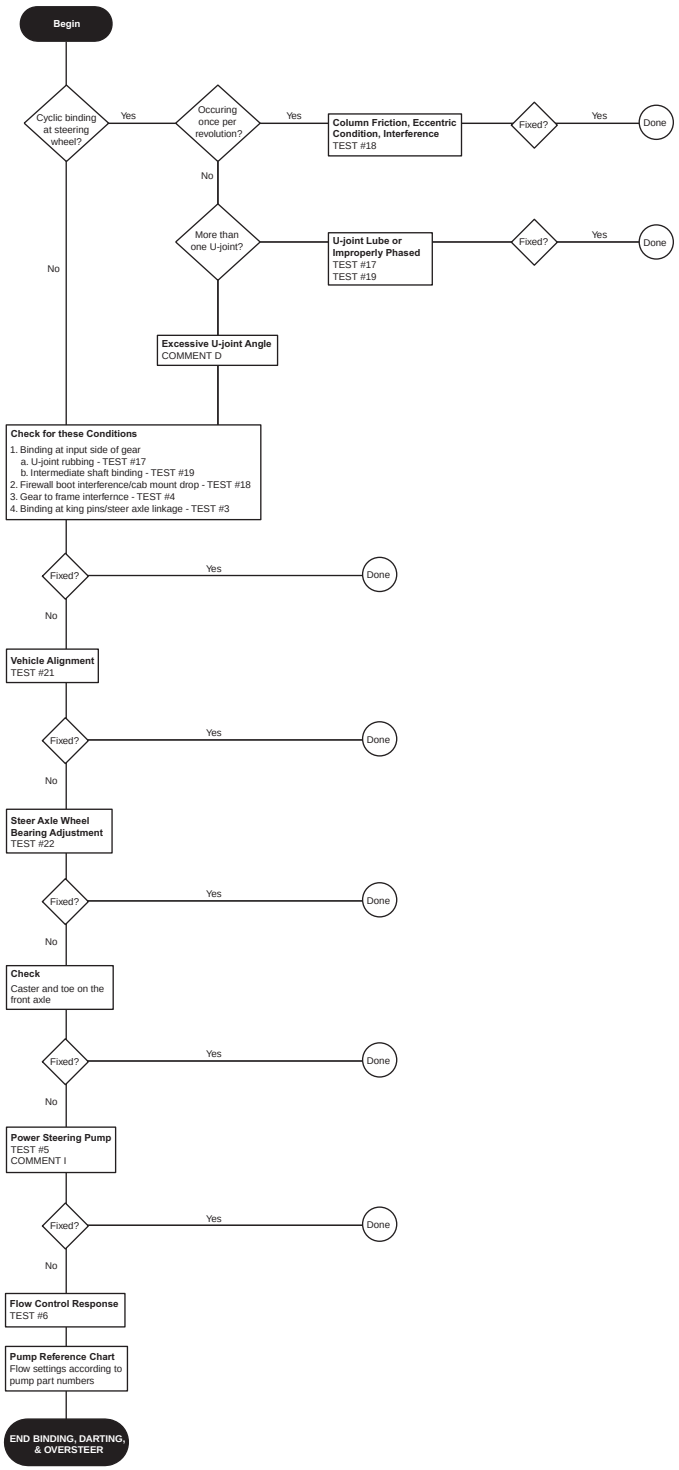
Reduced Wheelcut



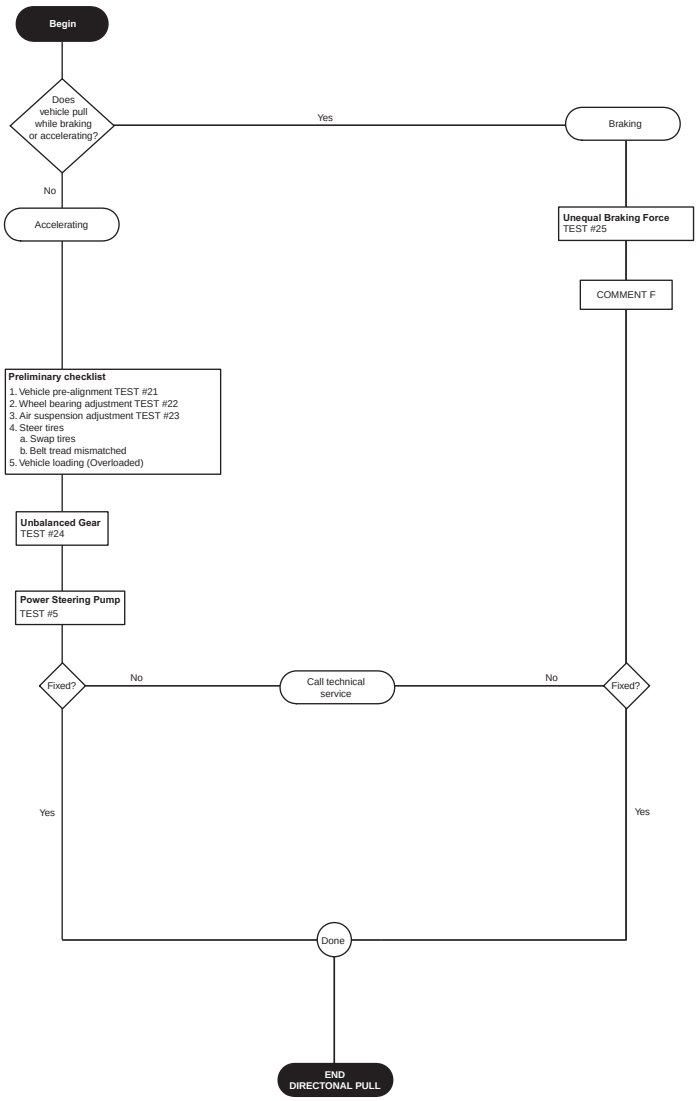
Steering Wheel Kick



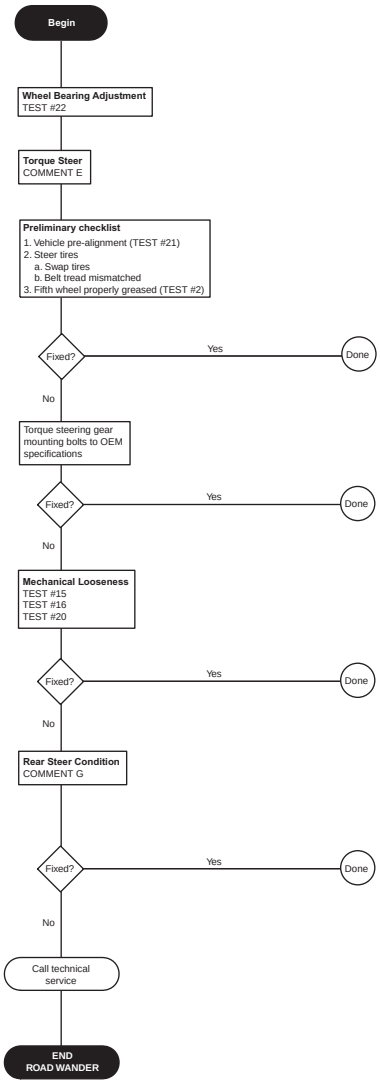
Binding, Darting, and Oversteer



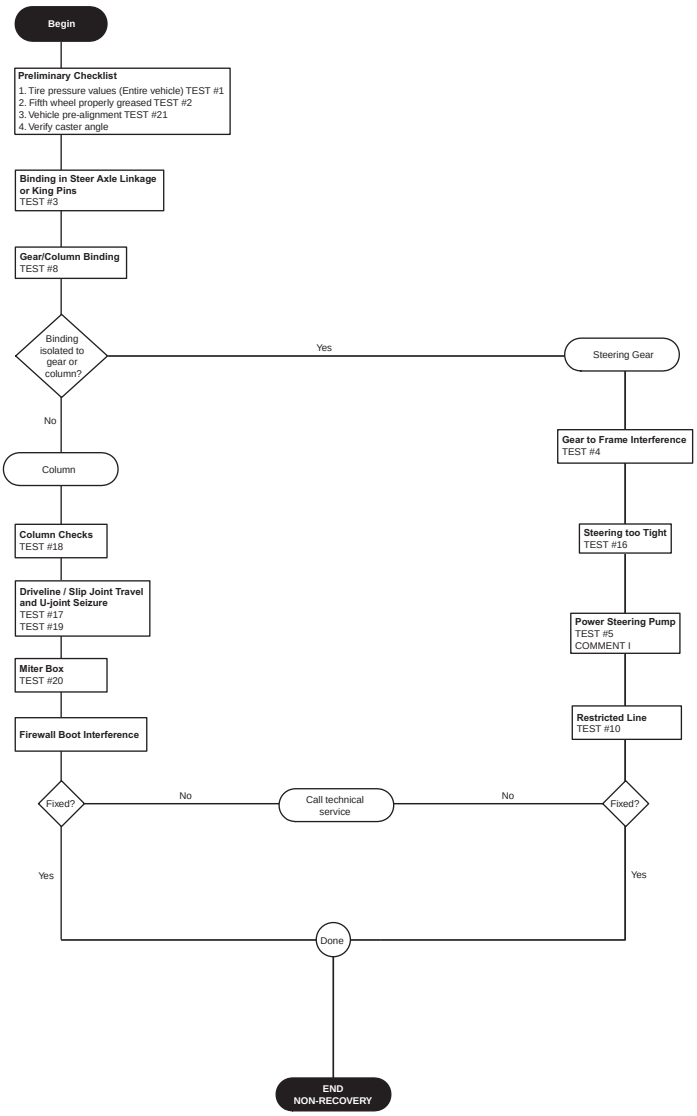
Directional Pull



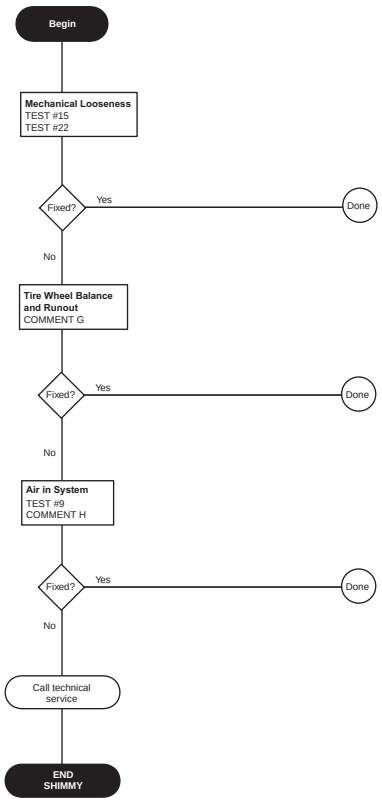
Road Wander/Loose Steering



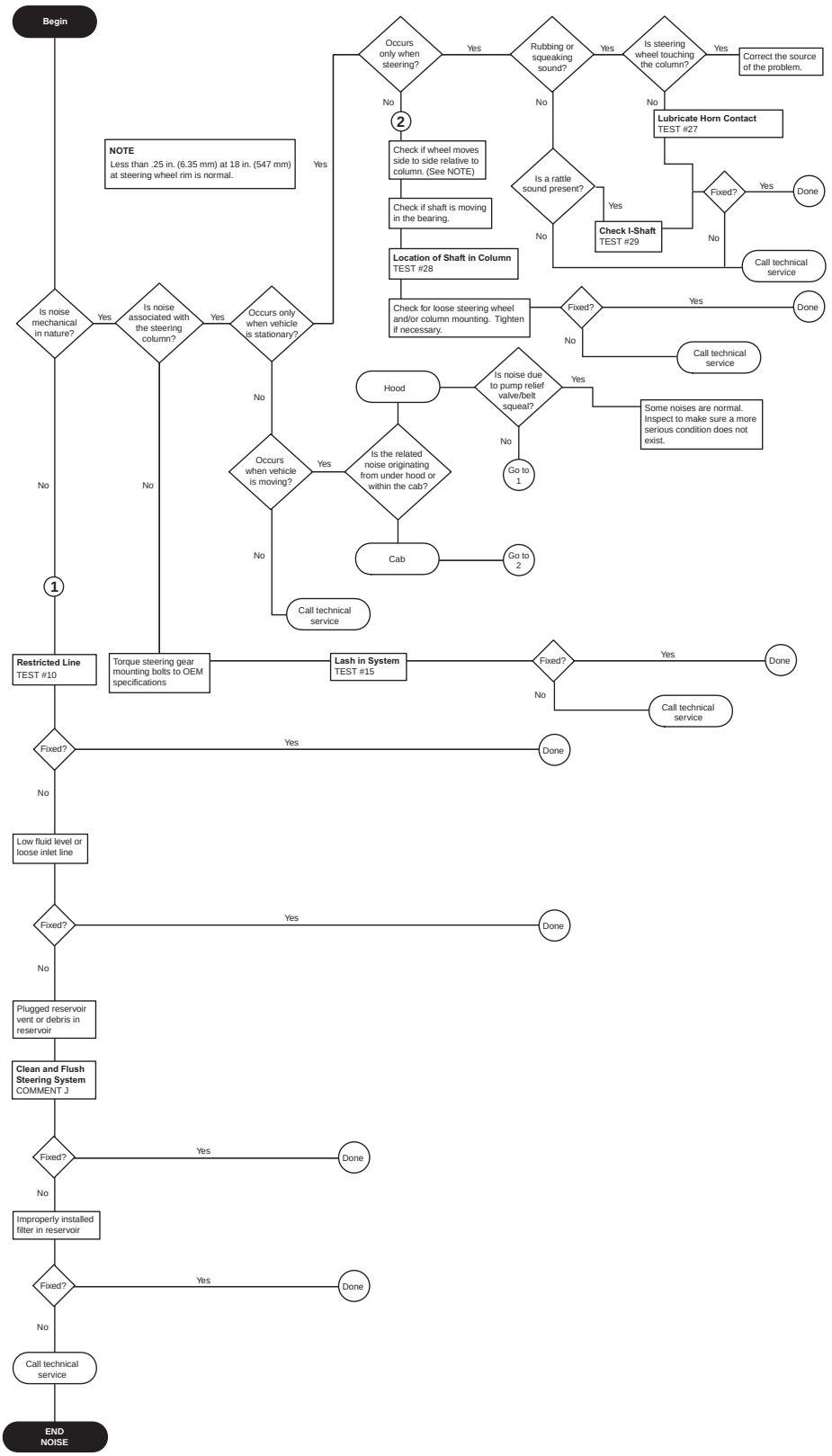
Non-Recovery



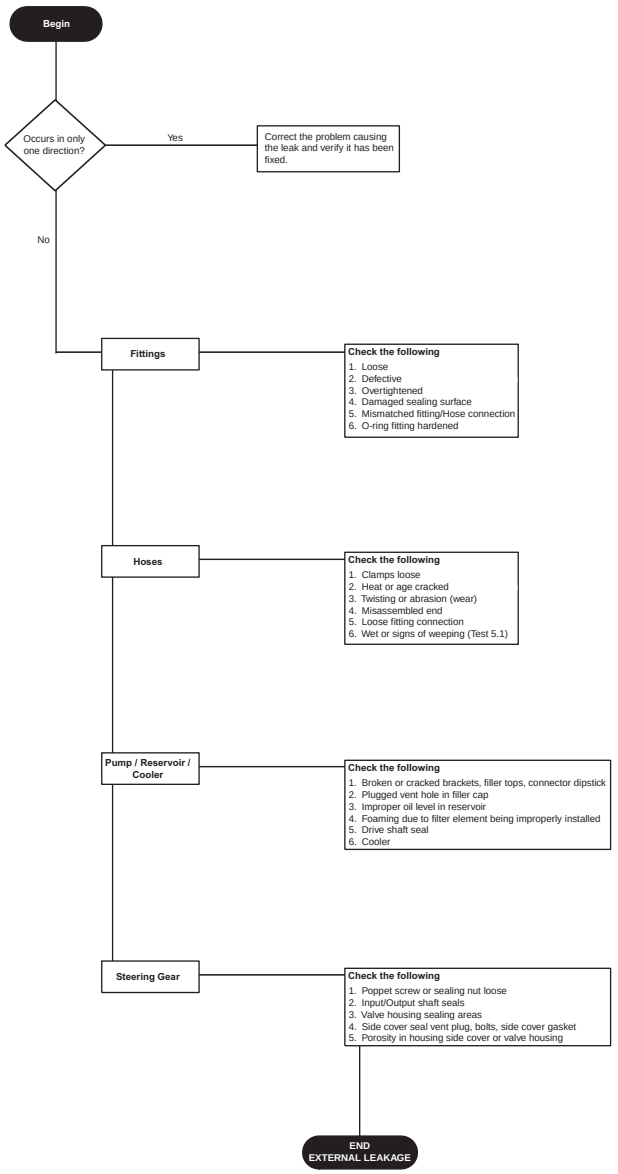
Shimmy


Begin
Mechanical Looseness
TEST #15
TEST #22
Fixed?
Yes
Done
No
Tire Wheel Balance and Runout
COMMENT G
Fixed?
Yes
Done
No
Air in System
TEST #9
COMMENT H
Fixed?
Yes
Done
No
Call technical service
END SHIMMY

Noise


Begin
Occurs only when steering?
Yes
Rubbing or squeaking sound?
Yes
Is steering wheel touching the column?
Yes
Correct the source of the problem.
No
No
No
2
Lubricate Horn Contact TEST #27
NOTE
Less than .25 in. (6.35 mm) at 18 in. (547 mm) at steering wheel rim is normal.
Yes
Check if wheel moves side to side relative to column. (See NOTE)
Is a rattle sound present?
Yes
Fixed?
Yes
Done
Check if shaft is moving in the bearing.
Check I-Shaft TEST #29
No
No
Location of Shaft in Column TEST #28
Call technical service
Is noise mechanical in nature?
Yes
Is noise associated with the steering column?
Yes
Occurs only when vehicle is stationary?
Check for loose steering wheel and/or column mounting. Tighten if necessary.
Fixed?
Yes
Done
No
Call technical service
Hood
Is noise due to pump relief valve/belt squeal?
Yes
Some noises are normal. Inspect to make sure a more serious condition does not exist.
No
Go to 1
No
No
Occurs when vehicle is moving?
Yes
Is the related noise originating from under hood or within the cab?
No
Cab
Go to 2
No
1
Call technical service
Restricted Line TEST #10
Torque steering gear mounting bolts to OEM specifications
Lash in System TEST #15
Fixed?
Yes
Done
No
Call technical service
Fixed?
Yes
Done
No
Low fluid level or loose inlet line
Fixed?
Yes
Done
No
Plugged reservoir vent or debris in reservoir
Clean and Flush Steering System COMMENT J
Fixed?
Yes
Done
No
Improperly installed filter in reservoir
Fixed?
Yes
Done
No
Call technical service
END NOISE

External Leakage



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Section 3 Test Procedures

Test #1 - #3 20
Test #4 21
Test #5 22
Test #5.1 23
Test #6 24
Test #6.1 25
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Test #11 - #14 29
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Test #17 - #19 31
Test #20 - #25 32
Test #26 - #29 33

Test #1
Steer Tire Check

1. Look for: Tire damage, Uneven or extreme tread wear, mismatched tires or other wear indicators that would cause the problem. *Figure 1.1.*

2. Check tire pressures on steer axle tires. *Figure 1.2.*

Figure 1.1

Figure 1.2

Test #2
Fifth Wheel and Trailer Plate

1. Look for dry fifth-wheel or trailer plate. *Figure 2.1.*

2. Look for damage to fifth-wheel or trailer plate. *Figure 2.2.*

3. Inspect fifth-wheel for looseness.

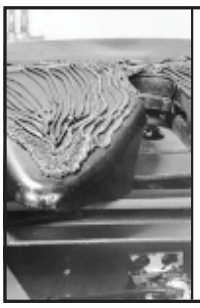

Figure 2.1

Figure 2.2

Test #3
Steer Axle and Linkage Binding

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link or pitman arm from the steering gear, (and linkage from assist cylinder if there is one on the vehicle). *Figure 3.1.*

⚠ CAUTION **Do not steer the gear with linkage removed, as misadjustment of automatic poppets may result.**

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. *Figure 3.2.*

3. Repeat the test in the opposite direction.

4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

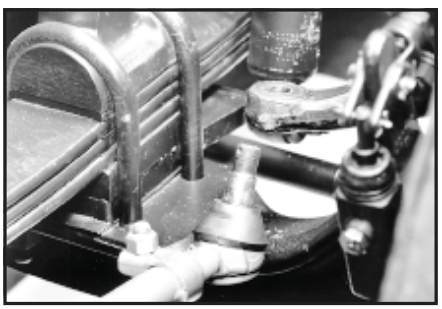

Figure 3.1

Figure 3.2

Test #4
Steering Gear Mounting

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame, frame flanges or spring mounting points. *Figure 4.1.* Mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adapter, sector shaft adjusting screw and nut contact with access adjustment hole in frame. If interference is found, correct the problem.

2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. *Figure 4.2.* Checking to see if distortion is present on the vehicle may require the following test:

3. With vehicle parked and engine running, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt (stop engine loosen one mounting bolt restart engine) and steer the vehicle again. Continue to loosen one mounting bolt at a time, shutting off engine each time, and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection the condition causing the gear to distort and correct the problem. Distortion of .030" (.80 mm) or less is acceptable. If greater than .030" (.80 mm) surface flatness, condition must be corrected.

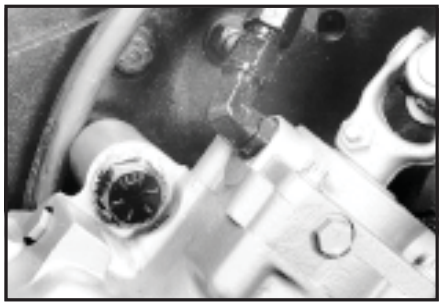

Figure 4.1

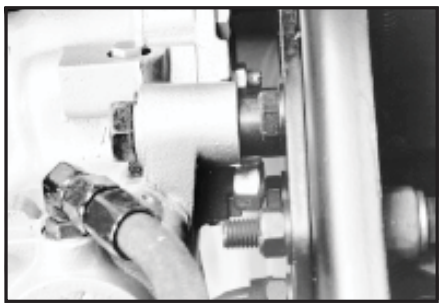

Figure 4.2

Test #5
Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5**, located in the "TEST RESULTS" section.

Verify Engine Idle speed per your OEM specifications.

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.*

2. Run the engine at 1000 rpm.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gauge. Do not allow the system to exceed 3000 psi (207 bar) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build- up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows (and the relief pressure you measured) to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

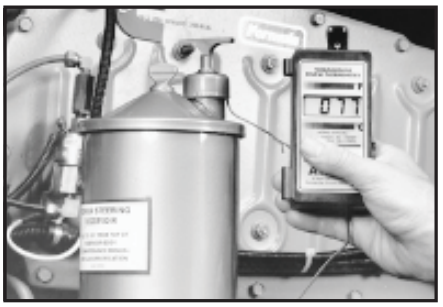
Figure 5.1

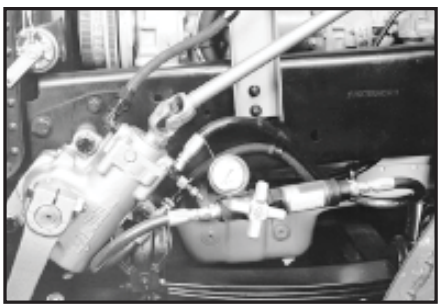
Figure 5.2

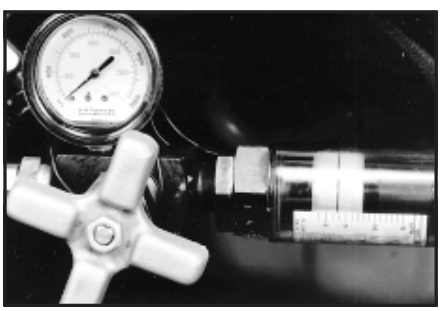
Figure 5.3

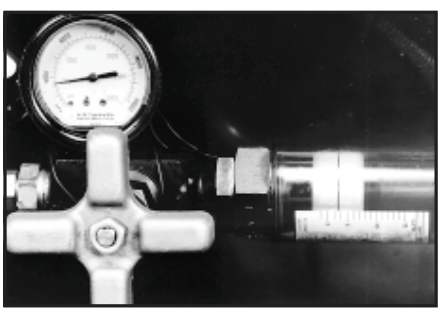
Figure 5.4

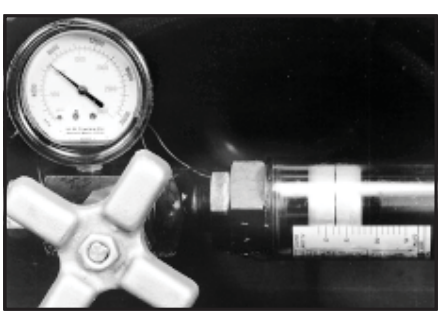
Figure 5.5

Test #5.1
40 Minute Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5.1** in the "Test Results" section.

Verify Engine Idle speed per your OEM specifications

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250° F (121° C).

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 3000 psi (207 BAR) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum

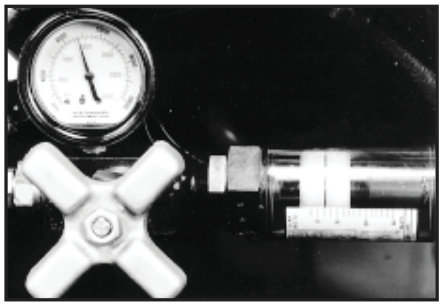

Figure 5.6

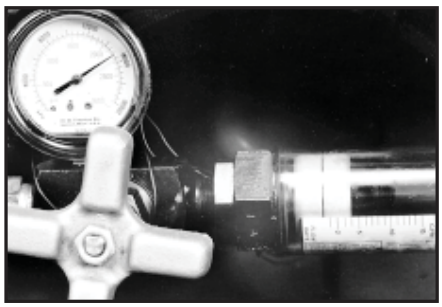

Figure 5.7

system pressure is lower than that specified for the pump (refer to your OEM service manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #6
Pump Flow Control Response

IMPORTANT: Read the following instructions below before completing **Table 6**, in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.*

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

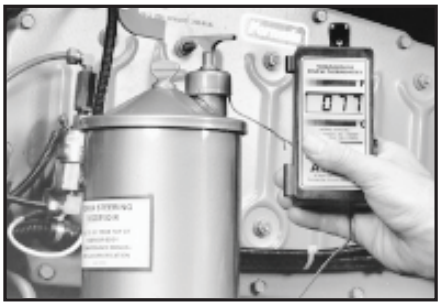

Figure 6.1

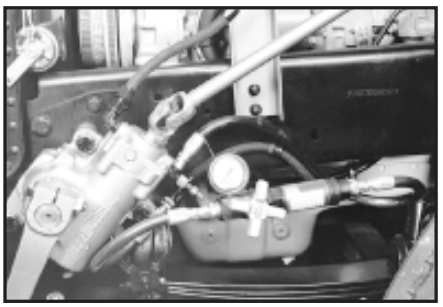

Figure 6.2

Test #6.1
40 Minute Pump Flow Control Response

Read the following instructions below before completing **Table 6.1** in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30, and 40 minutes. Do not allow the temperature to exceed 250° (121°C)

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

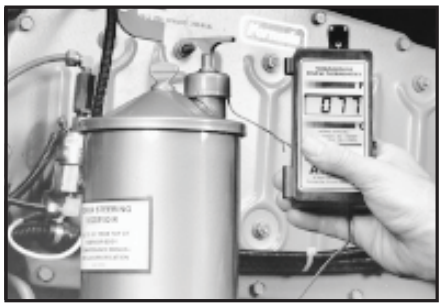

Figure 6.1

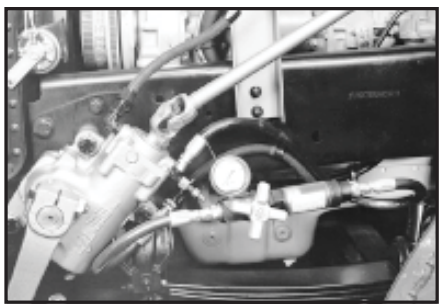

Figure 6.2

Test #7
Measured Internal Leakage

1. Install temperature gauge in reservoir. *Figure 7.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 7.2.*

⚠ WARNING	**THIS TEST CAN BE DANGEROUS IF NOT PERFORMED CORRECTLY. KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

2. To test the steering gear for internal leakage, you must first prevent operation of the gear's internal unloading (poppet) valves or relief valve (or both, in some gears). This will allow full pump relief pressure to develop. To prevent operation of the poppets, place an unhardened steel spacer block, about one inch thick and long enough to keep your fingers clear between the axle stop at one wheel. *Figures 7.3-7.4.* To prevent operation of the relief valve, remove the relief valve cap, o-ring and two piece relief valve, if equipped, from valve housing. Install the relief valve plug, special tool number J37130 in its place.

NOTE	Be sure you reinstall the relief valve and valve cap with new o-ring, back onto the gear after leakage test.

⚠ CAUTION	**When running this test, do not hold the steering wheel in the full turn position for longer than 5 to 10 seconds at a time to avoid damaging the pump.**

⚠ WARNING	**KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

3. With the fluid temperature between 125-135° F (52-57° C), turn the steering wheel until the axle stop bolt contacts the spacer block.

4. Apply 20 pounds of force to the rim of the steering wheel during this test to be sure that the steering gear control valve is fully closed. *Figure 7.5.* The pressure gauge should now read pump relief pressure, as noted during the Flow Control Response Test (Test #6). You can now read steering gear internal leakage on the flow meter.

5. Repeat this test for the opposite direction of turn.

6. If internal leakage is greater than 1 gpm (3.8 lpm) and there is no auxiliary hydraulic linear or rotary cylinder in the system, repair or replace the gear. If the internal leakage is greater than 2 gpm (7.6 lpm), and there is an auxiliary hydraulic linear or rotary cylinder in the system, controlled by the gear, isolate the auxiliary cylinder from the system by disconnecting the auxiliary cylinder hydraulic

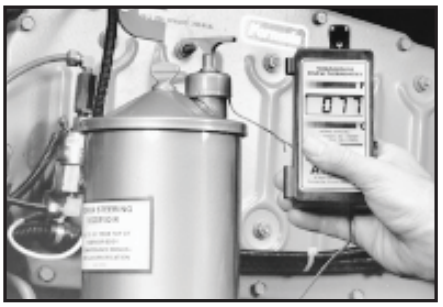
Figure 7.1

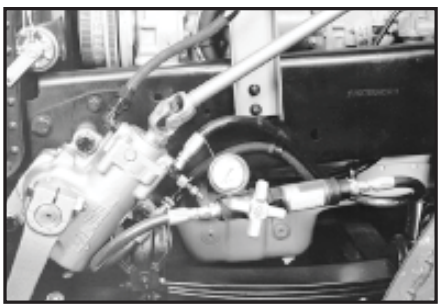
Figure 7.2

Figure 7.3

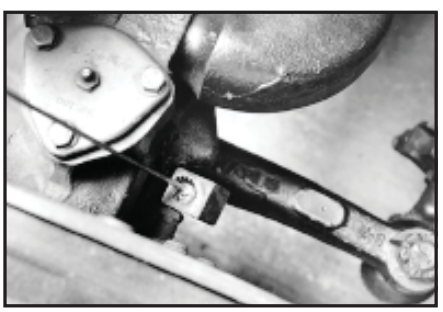
Figure 7.4

Figure 7.5

lines at the gear auxiliary ports. Plug the steering gear ports with suitable steel or high pressure plugs or caps.

In the event that a rotary cylinder is used in the system, connect the disconnected lines together with a suitable union fitting. In the case of a linear cylinder, first plug the disconnected lines and then disconnect the cylinder from the steering linkage, making sure it will clear the steered axle. *Figures 7.6-7.7.*

Repeat the internal leakage test. If the internal leakage is less than 1 gpm (3.8 lpm), repair or replace the auxiliary cylinder. If the internal leakage is greater than 1 gpm (3.8 lpm), repair or replace the gear.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #8
Steering Column Binding

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. *Figure 8.1*

3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. *Figure 8.2* If binding is not felt, correct the steering column problem.

Test #9
Air in Hydraulic System

1. Inspect reservoir for foaming or air bubbles. *Figure 9.1* If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings. Look for oil level changes engine off versus engine on, if fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

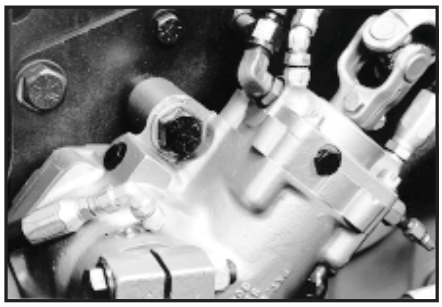
Figure 7.6

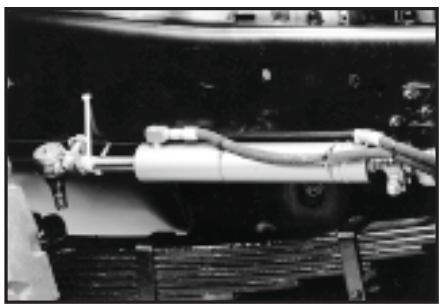
Figure 7.7

Figure 8.1

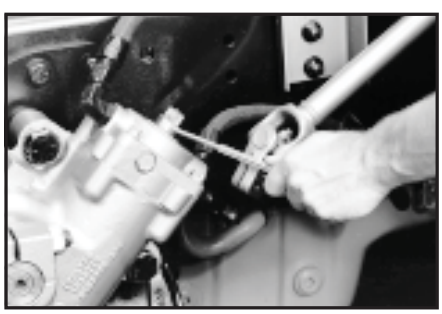
Figure 8.2

Figure 9.1

Test #10
Restricted Hydraulic Line

Read the following instructions below before completing **Table 10**, in the "Test Results' section

1. Look at the supply line that goes to the pump to check for kinking or any other obstructions or irregularities on the inside of the hose. *Figure 10.1.*

2. Install PSSA with load valve fully open. *Figures 10.2-10.3.* Insert temperature gauge into reservoir. With oil between 125-135 °F (52-57 °C), determine a test engine speed (RPM) that causes pump to deliver 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) (whichever is easier) and note this speed.

3. Remove the PSSA and install a low pressure gauge (200-300 psi (14-21 bar)) maximum with approximately 10 psi (.70 bar) per division) in the pressure line to the steering gear at the pump end. Install a temperature gauge in the power steering reservoir.

⚠ CAUTION	**Do not allow system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge will result. Extremely high restrictions may be indicated with the PSSA gauge as installed with load valve fully open.**

NOTE	Be sure that the steering gear input shaft is not being restrained from recentering because this will cause a false steering gear pressure drop. If there is any question, conduct this test with the steering column removed.

4. Bring the power steering fluid temperature to 125-135 °F (52-57 °C), at engine idle, with no steering force applied to the steering wheel. *Figure 10.4.*

5. At the test engine speed selected from step 2 above, measure and record the gauge reading and shut off the engine. This measures total system pressure.

6. Remove the pressure and return lines from the steering gear and connect them together with a fitting that will not restrict the flow. *Figure 10.5.*

7. Start the engine, and run at the RPM identified in step 2 with the fluid temperature between 125-135 °F (52-57 °C).

8. Measure and record gauge reading and shut off engine. This is hydraulic line/reservoir pressure.

9. The difference between the total system pressure gauge reading and the hydraulic line/reservoir pressure gauge reading is the steering gear pressure drop. For a TRW steering gear, at a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm), the drop should not be greater than 30, 40, 55 or 70 psi (2.0, 2.8, 3.8, 4.8 bar) respectively. The line/reservoir pressure drop for a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) should not be greater than 20, 20, 25 or 25 psi (1.4, 1.4, 1.7, 1.7 bar) respectively.

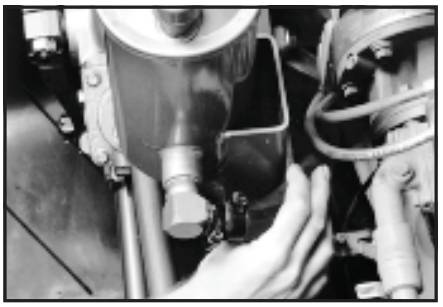
Figure 10.1

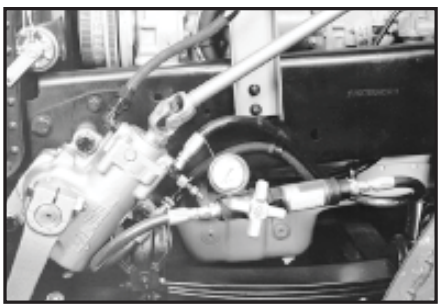
Figure 10.2

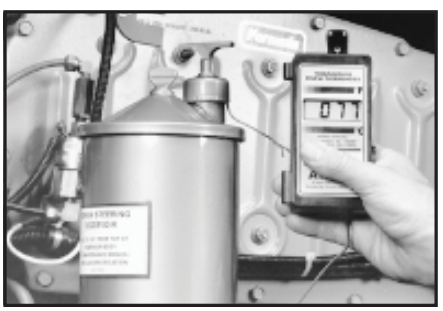
Figure 10.3

Figure 10.4

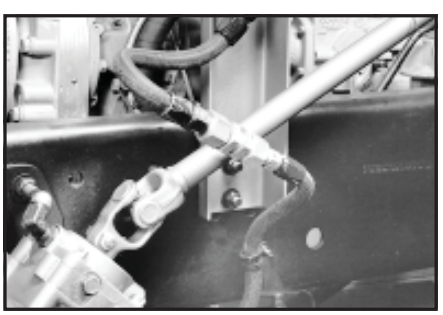
Figure 10.5

Test #11
Axle Stop Setting

Put vehicle steer tires on radius plates (turntables). Check to make sure axle stops are set to manufacturer's specifications. *Figure 11.1.*

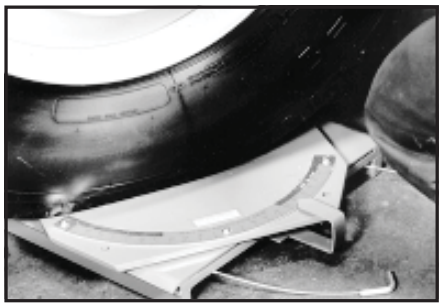
Figure 11.1

Test #12
Pitman Arm and Output Shaft Alignment

Look to make sure the output shaft timing mark is lined up with the pitman arm timing mark. Some pitman arms have more than one mark, so make sure the right one is used. *Figure 12.1.*

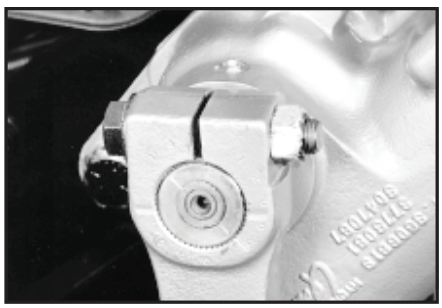
Figure 12.1

Test #13
Misadjusted Drag Link

The length of the drag link must be correct for the steering system. Check the length after you make sure the pitman arm/ shaft timing marks are aligned, the gear is at its center position, and the road wheels are straight ahead. *Figure 13.1.*

Test #14
Poppet Setting Procedure

1. If you are working on a newly-installed TAS steering gear, refer to the service manual to correctly set the poppets. If you are working on a steering gear, other than a TAS series, refer to the OEM's service manual for correct poppet setting instructions.

2. To set poppets on a TAS series gear using the adjustable service kit, refer to your steering gear service manual.

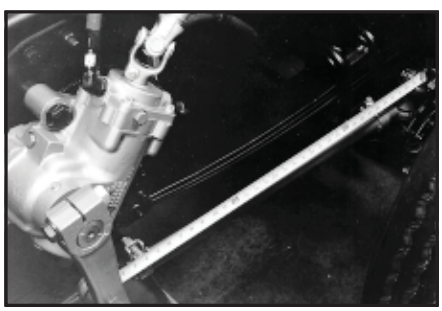
Figure 13.1

Test #15
Lash in Steering System

Two people are needed for this test. One person will slowly turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: *Figures 15.1-15.5.*

* Steering wheel to steering column
* U-joints, or slip-joint and/or miter boxes
* Steering column to steering gear input shaft
* Steering gear input shaft to steering gear output shaft
* Pitman arm to output shaft
* Drag link to pitman arm connection
* Drag link ends (sockets) and adjustable areas
* Axle arm to drag link connection
* King pin axle connections (bushings)
* Tie rod arms to tie rod connection
* Tie rod ends (sockets) and adjustable areas
* Steering spindle
* Wheel bearings
* Lug nuts
* Spring pin connectors
* Front axle u-bolts
* Spring hanger brackets/rear shackles

NOTE	Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

NOTE	Be sure to check rear drive axles for any looseness and inspect tires for signs of abnormal wear.

Test #16
Steering Gear Adjustment

Check and adjust according to the appropriate service manual for your steering gear if necessary

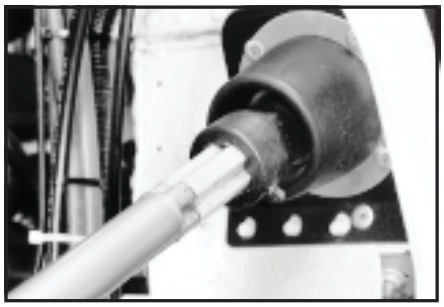
Figure 15.1

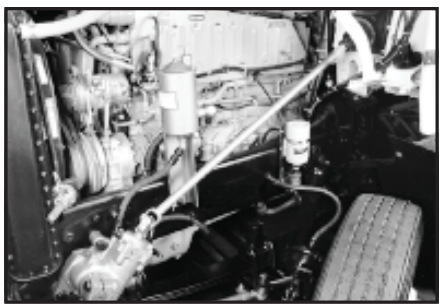
Figure 15.2

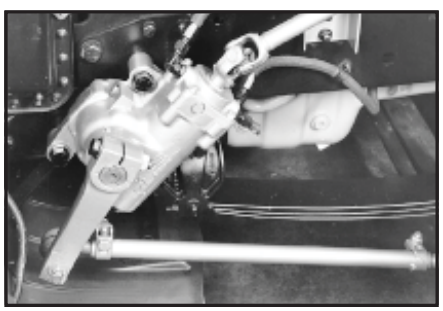
Figure 15.3

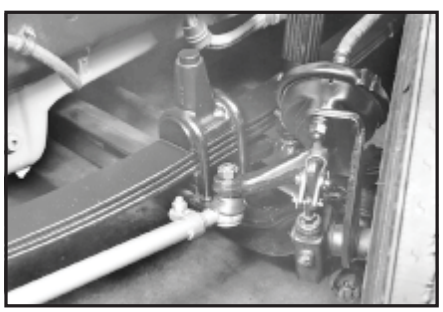
Figure 15.4

Figure 15.5

Test #17
U-Joint Phasing and Lubrication

1. Make sure u-joints are properly lubricated.

2. Steering column assemblies with more than one universal joint (cardan type) can cause a cyclic binding feel or torque variation at the steering wheel if the u-joints are not in phase with each other. *Figure 17.1-17.2*. If a steering column assembly with multiple u-joints is taken apart, it must be reinstalled with the timing marks for slip mechanisms aligned. This is true for both the cross-type and the splined-type two-piece intermediate shaft.

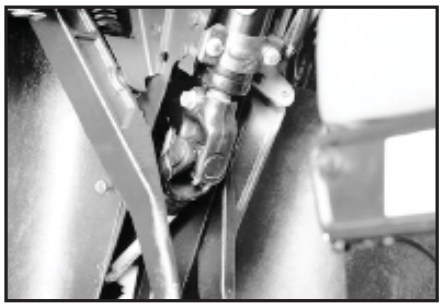

Figure 17.1

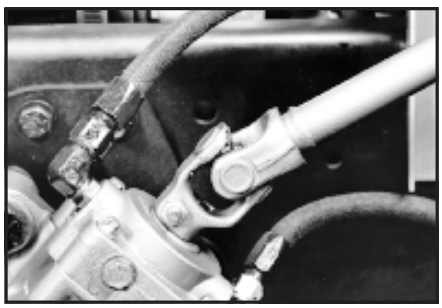

Figure 17.2

Test #18
Steering Column Interference

Position steering wheel at the location where steering wheel interference is noticed, and look for something interfering or rubbing on the rotating column assembly such as brackets, bolts, floorboard, boot, etc.

Test #19
Intermediate Column Interference

1. Check the slip column by looking to make sure there is proper travel allowance when in use. *Figure 19.1.*

2. Look for wear or galling. *Figure 19.2.*

3. Check slip column for too much slip force

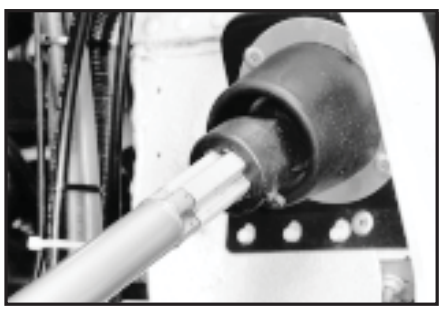

Figure 19.1

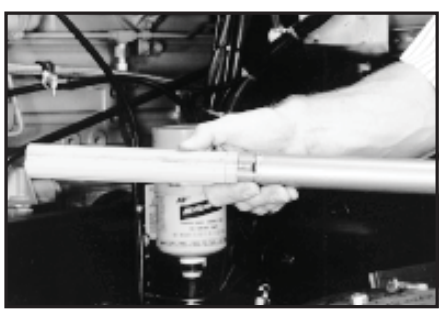

Figure 19.2

Test #20
Miter Box Misadjusted (if equipped)

Check and adjust per manufacturer's instructions. *Figure 20.1.*

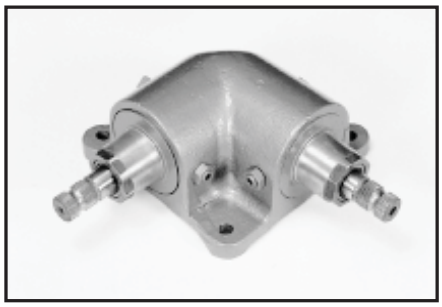

Figure 20.1

Test #21
Vehicle Alignment

Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). *Figure 21.1.*

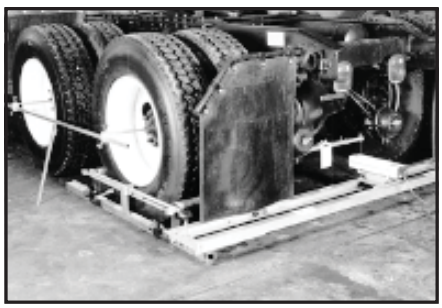

Figure 21.1

Test #22
Wheel Bearing Adjustment

Verify that adjustment is made according to manufacturer's specification. *Figure 22.1.*

Figure 22.1

Test #23
Air Suspension Adjustment

Check and set to manufacturer's specifications

Test #24
Gear Imbalance

1. Install a low pressure gauge (200-300 psi (14-21 bar) maximum with approximately 10 psi (.70 bar) per division) in the pressure line from pump to gear. *Figure 24.1.*

⚠ CAUTION **Do not allow system pressure to exceed the rating of the gauge in the following procedure or damage to the gauge will result.**

2. At engine idle, slightly turn the steering wheel one direction until a pressure rise is observed at the gauge. *Figure 24.2.*
3. Stop steering and gently allow the steering wheel to recenter.
4. Next slightly turn the steering wheel the opposite direction while observing the gauge and determine if pressure initially rises or falls with initiation of a turn.
5. Repeat test a few times in each direction.
6. If a consistent fall in pressure is associated with the initiation of a turn in one direction, the steering gear's control valve is unbalanced and needs to be replaced.

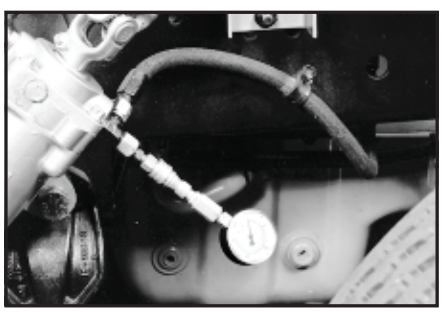

Figure 24.1

Test #25
Unequal Brake Force

Visually inspect brake assemblies for oil/grease on braking surfaces, and overall condition of brake surfaces. Adjust or replace brakes if necessary.

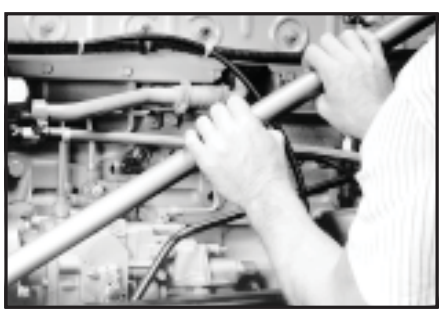

Figure 24.2

Test #26
Tire Balance / Runout

Have wheel assemblies balanced and checked for lateral and radial run out per manufacturer's specifications. Preferred method for checking balance is with wheels still on the vehicle. Balance includes total rotating assembly.

TEST #27
Steering Column Noise

If column does not include a clockspring, remove steering wheel and add dielectric grease to the horn contact. The grease TRW uses is Model No. K-5/X Semifluid CA, product code 134613, from Century Lubricants. If noise continues, check steering wheel and shroud (not applicable to columns with clockspring).

TEST #28
Steering Column Bearing

Check upper bearing gaskets. Gaskets should cover bearing.

TEST #29
Intermediate Column Lash

Check intermediate column (I-Shaft) for torsional lash in U-Joints of slip section. Replace intermediate column if necessary.

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Section 4 Comments

Comment A - H 36
Comment I - K 37

Comment A
Some power steering pumps have a temporary state during which the pumping element vanes do not extend. Usually increasing engine speed briefly will correct the problem.

Comment B
The maximum speed of steer with power assist for a power steering gear is limited by the pump flow and internal leakage. Example: Recommended minimum flow for a new TAS65 steering gear is 3.0 gpm (11.4 lpm), and is based on a maximum steering speed capability of 1.5 steering wheel turns per second.

Comment C
Vehicle linkages are designed to minimize the affect at the steering gear and steering wheel during normal steered axle/suspension movements. Be sure that linkage used is as specified by vehicle manufacturer.

Comment D
A single u-joint operating at an angle will cause a cyclic torque variation at the steering wheel. The amount of torque variation increases with the amount of operating angle. A secondary couple that side loads the input shaft also increases with increased u-joint angles. U-joint operating angles of 15 degrees or less will minimize the torque variation felt at the steering wheel.

Comment E
Deflections in the suspension and linkage, front and rear, due to high engine generated torque levels can cause a steering effect. This most often occurs at lower vehicle speeds while accelerating.

Comment F
The location of the axle arm ball center is important during spring wind-up conditions such as severe braking. A steering arm different from that specified by the manufacturer could cause a steering effect while braking.

Comment G
Soft or loosely supported rear suspensions may allow the rear driving axles to become non-square with the centerline of the chassis during load shifting or trailer roll which will tend to produce a steering effect.

Comment H
Power steering pump cavitation

Pump cavitation is defined as a "wining" or noisy power steering pump. Usually, pump cavitation is most noticed during engine start-up at low temperature extremes. However, other conditions can cause the power steering pump to continually cavitate and cause internal pump damage, and ultimately, failure. These conditions are:

1. Twisted, loose, or cracked inlet line
2. Inlet line blockage due to:
    a. Contamination - dirt and foreign material
    b. Damaged filters
    c. Reservoir components
    d. Inner hose liner separation
3. Displaced (improper or improperly installed) filters
4. Reservoir cap "vent" plugged

Comment I
Excessive Flow

TRW steering gears are rated for 8 gpm maximum power steering pump flow. Although the gears have the capability to handle this maximum flow, it is not always a system need or requirement. When using combinations of dual gears or a single gear with a hydraulic linear cylinder, supply flows for both components should be considered (See Steering Gear Flow Requirements). Single gear applications have a recommended flow at engine idle. For acceptable steering speed performance, again, refer to the Steering Gear Flow Requirements. Increasing the engine idle flow by more than 50% of the recommended flow can cause power steering system overheating, vehicle directional control problems (Darting), and steer axle returnability (Non-recovery). If you measure idle flows above the 50% limit, consult your OEM for guidance and recommendations.

Comment J
Flushing and Air Bleeding the System

IMPORTANT: Clean the area around the reservoir, steering gear and pump thoroughly before beginning this procedure.

1. Set parking brake on vehicle and block rear wheels.
2. Raise the front end off the ground
3. Take vehicle out of gear and put into neutral position
4. Raise hood and place a drip pan under the steering gear
5. Remove both the pressure and return lines from the steering gear
6. Remove filter from the power steering fluid reservoir and discard

IMPORTANT: Discard only the filter, other components may be required to hold filter element in place inside the reservoir.

7. Clean the inside of the reservoir
8. Turn steering wheel from full left to full right 3-4 times. This will purge the oil from the steering gear.
9. Reconnect pressure and return lines to the steering gear and tighten
10. Install new filter element into the reservoir
11. Clean reservoir filler cap with an approved solvent. Inspect gasket and replace if necessary.
12. Fill reservoir with approved replacement fluid and reinstall the filler cap
13. Start engine for 10 seconds, stop, and check reservoir fluid level and top off if necessary. You may need to repeat this procedure 3 or 4 times.
14. Upon completion of filling the reservoir, start the engine and let it idle. At engine idle, steer full right and full left once and return to straight ahead. Stop engine and check power steering reservoir level and top off if required.
15. Restart engine and steer full turns each direction 3 or 4 times.
16. Stop engine and recheck reservoir fluid level and adjust to correct level, if needed.
17. Inspect system for leaks and correct if necessary
18. Bleed air from the system if required (Refer to your steering gear service manual for recommended air bleeding procedures.)
19. Remove drip pan and lower vehicle. Remove blocks from wheels and release vehicle for normal service.

Comment K
Identifying “Burnt Oil”

Sometimes the power steering reservoir oil supply will become hotter than the normal operating temperature and overheat. This condition may result in an intermittent loss of power assist and also cause deterioration of the power steering hoses and component seals. TRW recommends that the power steering hoses be examined for deterioration due to overheated oil, which can be identified by wet hoses, and determine the condition of the reservoir fluid by looking for signs of “burnt oil.”

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Section 5 Test Results

Test 5 - Power Steering Pump Test 40
Test 5.1 - 40 Minute Power Steering Pump Test 40
Test 6 - Flow Control Response Test 41
Test 6.1 - 40 Minute Flow Control Response Test 41
Test 10 - Restricted Hydraulic Line Test 42
Steering Gear Flow Requirements 43
Pump Part Number Reference Guide 44

Test 5.0 - Power Steering Pump Test

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.0

Test 5.1 - 40 Minute Power Steering Pump Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	˚F or ˚C

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.1

Test 6.0 - Pump Flow Control Response Test

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.0

Test 6.1 - 40 Minute Pump Flow Control Response Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	°F or °C

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.1

Test 10.0 - Restricted Hydraulic Line Test

With PSSA @ 125 - 135 F (52 - 57 C)	RPM	GPM or LPM
With pressure gauge at pressure line to steering gear at pump end	RPM	GPM or LPM
Remove pressure and return lines and measure pressure with gauge at pump outlet	RPM	PSI or BAR

Table 10.0

Steering Gear Flow Requirements

Single Gear

Gear	GPM	LPM
TAS40, THP/PCF45, HFB52	2.2	8.3
TAS55, THP/PCF60	2.6	9.8
TAS65 or HFB64	3.0	11.4
TAS85 or HFB70	3.6	13.6
RCS40	2.2	8.3
RCS55	2.6	9.8
RCS65	3.0	11.4
RCS85	3.6	13.6

Dual Gear

Gear	GPM	LPM
TAS65 w/ RCS65	6.0	22.7
TAS65 w/ Linear Cylinder	6.5	24.6
TAS85 w/ RCS85	7.0	26.5
TAS85 w/ RCS65	6.5	24.6
TAS85 w/ Linear Cylinder	6.5	24.6
HFB70 w/ RCB70	7.0	26.5
HFB70 w/ RCB64	6.5	24.6
HFB70 w/ Linear Cylinder	6.5	24.6

Pump Part Number Reference Guide

Check the part number on your TRW power steering pump and note the pump relief setting shown in the example below. (See illustration on where to find the pump part number). If the values that you have recorded are within +/- 100 psi (+/- 7 bar) your pump is functioning properly. If the values recorded are below the negative tolerance, your pump is malfunctioning and should be replaced.

For TRW power steering pumps, the relief setting will be the 5th and 6th numbers in the pump part number.

EV 18 12 15 R 1 01 00

Family designation
PS = PS Pump
EV = EV Pump

Displacement per revolution
18 = 18 cc (1.10 cir)
22 = 22 cc (1.34 cir)
25 = 25 cc (1.53 cir)
28 = 28 cc (1.71 cir)

Flow control
12 = 12 lpm (3.17 gpm)
14 = 14 lpm (3.70 gpm)
16 = 16 lpm (4.23 gpm)
20 = 20 lpm (5.28 gpm)
24 = 24 lpm (6.34 gpm)

Relief setting
09 = 90 bar (1305 psi)
10 = 100 bar (1450 psi)
12 = 120 bar (1740 psi)
14 = 140 bar (2030 psi)
15 = 150 bar (2175 psi)
16 = 160 bar (2320 psi)
17 = 170 bar (2465 psi)
18 = 185 bar (2683 psi)

Direction of rotation
R = clockwise rotation
L = counterclockwise rotation

Shaft type
1 = 11 tooth 16/32 spline
2 = .625 dia. woodruf key

Housing
Varies between PS and EV Series pump

Customer version
00 = Standard

TRW Automotive
Commercial Steering Systems
800 Heath Street
Lafayette, IN 47904
Tel 765.423.5377
Fax 765.429.1868
http://www.trucksteering.com
http://trucksteering.trw.com

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TRW1250 Rev. 4/02

Body Glass

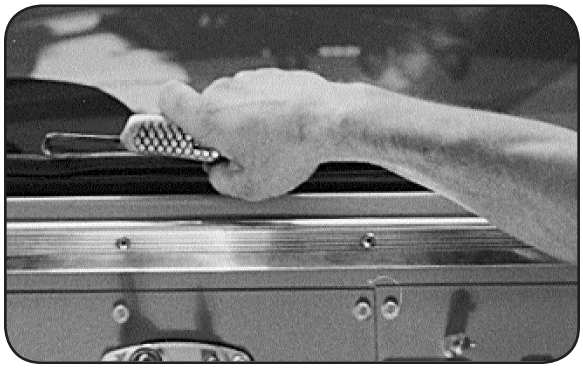
Glass replacement should meet standards in specification FMVSS 205 and 217.

WARNING ***When replacing broken or damaged glass, use extreme care at all times to prevent personal injury. Use proper replacement parts, tools and personal protective equip-ment, such as gloves and safety goggles.***

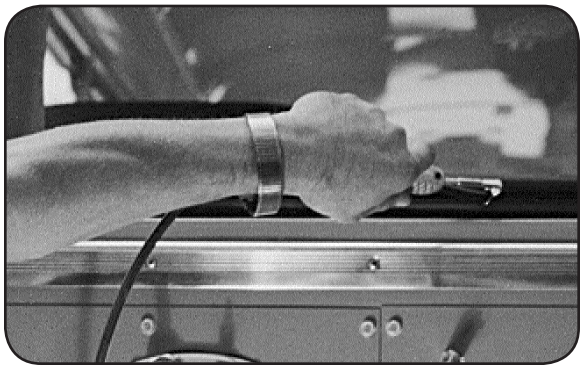
Windshield Glass Replacement

Remove vertical filler strip in glazing rubber on each side of broken glass. Remove horizontal filler strip in glazing rubber on top and bottom of broken glass. It will be necessary to cut the horizontal filler strip after it is pulled past the glass.

1. Starting at a corner, push glass free of glazing rubber from inside of bus outward and remove.
2. Position new glass in glazing rubber.
3. Using installation tool, work glass into glazing rubber.
4. Seal glass to glazing rubber from outside of the bus with an adhesive sealant, such as Silastic 732 RTV Adhesive/ Sealant.
5. Apply soapy solution to filler strip channel on glazing rubber to act as a lubricant for easier installation of filler strip.
6. Using filler strip tool, insert fillet strip into channel on glazing rubber.



Using glazing tool to help work gasket around windshield

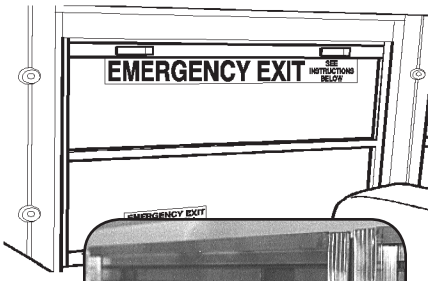


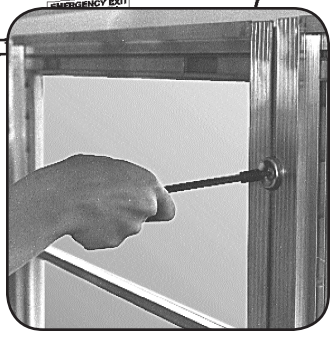
Applying the filler strip

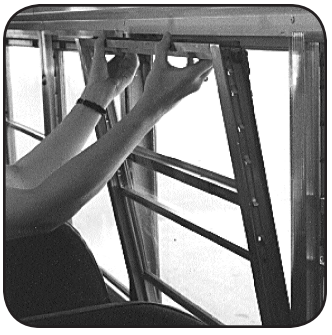
Split Sash Window and Glass Replacement

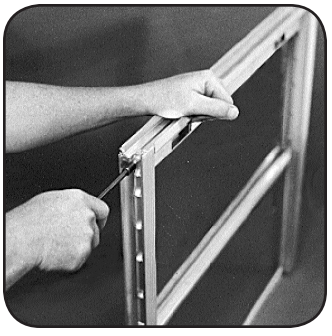
The glass used in the Blue Bird bus meets FMVSS 205 and 217. When a glass is broken, it should be replaced with identical glass.

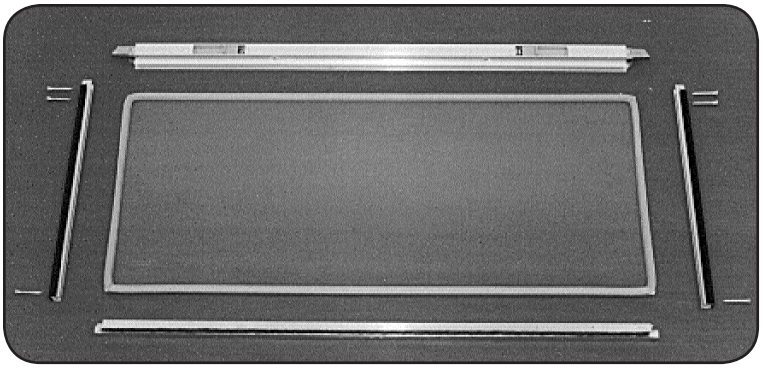
1. Remove four screws securing window frame to bow.
2. Pull window to inside of body and remove.
3. Remove six screws (three on each side of window) holding assembly together.
4. On bottom glass, simply pull aluminum channel off top and bottom of glass.
5. To remove glass from top part of window, remove 6 screws holding frame around glass.
6. Reassemble window by reversing above procedure.
7. Apply weather seal caulking around window frame to prevent leaking.

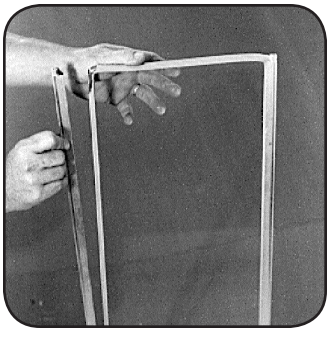




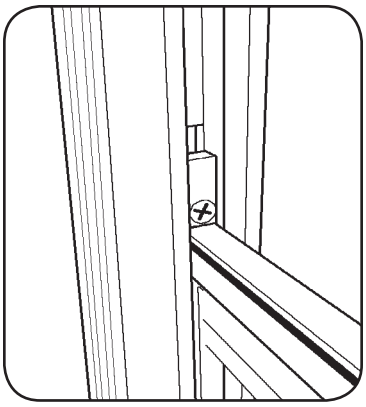




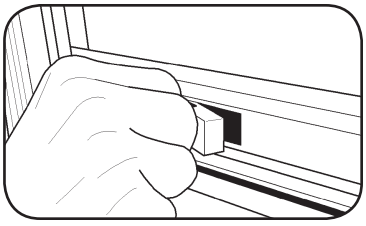




Window Latch Replacement



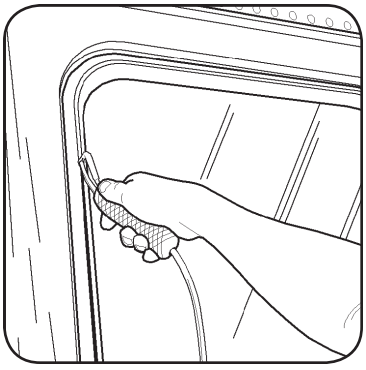
1. Remove screw and block located in side channel directly above stationary glass.
2. Lower sliding sash so that latch enters notch covered by block removed in Step 1.
3. With latch in large notch, push finger holes outward until inside edge is exposed. Pull latch out of finger hole opening.
4. Finger latch is pried off attached metal latch with any tool that provides leverage. Latch may now be removed and replaced.
5. Reassemble by reversing procedure.



Lubricate latches and sliding seal of top window with silicon spray every 30 days. See decal on driver's window.

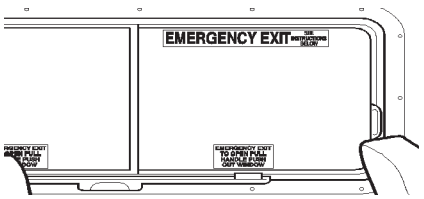
Rear Vision Glass Replacement

1. Remove filler strip from channel in glazing rubber.
2. Apply pressure against glass from the outside of the bus starting at a corner, push glass and glazing rubber off metal flange.
3. Remove glazing rubber from glass.
4. Put glazing rubber on new glass.
5. Apply a soapy solution to the flange on the bus body and to the filler strip channel on glazing rubber. This acts as a lubricant for easier installation.
6. Wrap a cord around the glazing rubber and rest the glass on the bottom window flange from the inside of the bus body. See Figure 6.



7. Apply pressure from the inside of the bus body to ensure glass is seated properly. Pull cord slowly and work glazing rubber onto the window flange.
8. Using a filler strip tool, insert the filler strip into the channel on the glazing rubber. The filler strip tool is available from your dealer. See Figure 7.
9. Apply clear caulking around glass and window flange on the outside of bus body to ensure that no leaks occur.

Transit Sliding Window Removal



1. Remove screws in outside aluminum extrusion.
2. Loosen sealer between window frame with putty knife.

CAUTION ***Do not pry window frame from body without loosening sealer. Unless sealer is loosened, window frame will be bent.***

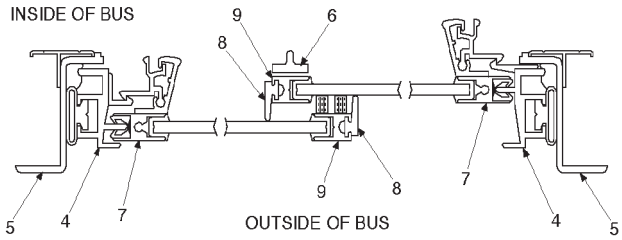
3. Pry out using screwdriver.
4. Reverse procedure for installation.

Transit Window Glass Replacement

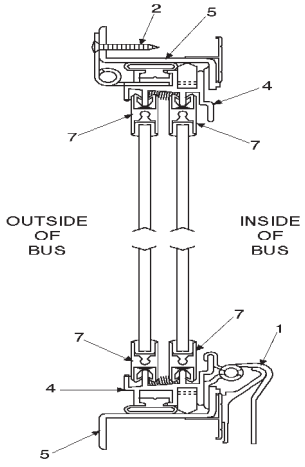
On push out windows, when hinge screws are removed and interior latch released, window sash may be removed from frame.

1. Release window lever (1) located inside the bus at the bottom of each push-out window.
2. Remove hinge screws (2) on outside of body.
3. Lift and pull window out of section.
4. To remove stationary transit sliding window, remove all screws between inner frame (4) and outer frame (5).
5. Lift and pull window out of section.
6. Remove four screws and take out vertical brace (6) located in the center of the window.
7. Remove two window stops (one on each side of the top of window).
8. Slide glass to the center of the window. Spread apart the inner frame (4) just enough to lift glass frame (7) out.
9. To remove glass from frame, slide rubber seal (8) out of vertical rail (9) exposing two screws. Window glass is removable after screws are removed. Remove glass.
10. To replace glass, slip glazing vinyl seal around glass and slide into frame.
11. Reassemble by reversing procedure.

Transit Sliding Window

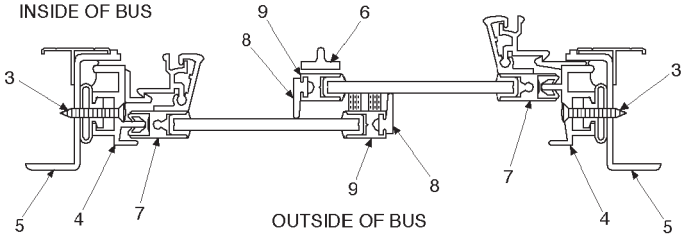


**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW PUSH OUT WINDOW**

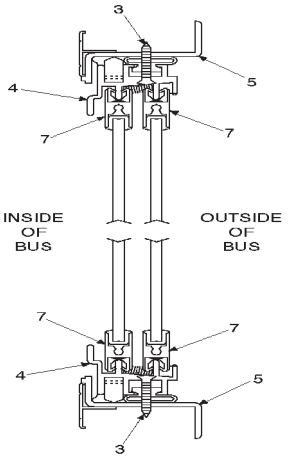


**VERTICAL SECTION THRU
TRANSIT SLIDING
PUSH OUT WINDOW**

Pushout Transit Sliding Window



**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW**



**VERTICAL SECTION
THRU TRANSIT
SLIDING WINDOW**

Outward Opening Entrance Door

The outward opening door panels are hung in a prefabricated framework before mounting into the body construction. The doors are suspended from sealed ball bearings located at the upper corners of the door. These components are accessible only from inside the body.

The bronze bearings at the lower corners of the door assembly are not weight bearing, but serve to hold the bottom of the assembly in position. These bronze bearing are permanently lubricated and should require little maintenance during the service life of the door assembly, which exceeds 300,000 cycles.

The interlink between the door panels is installed as a single assembly in the door header, and is adjustable for maintaining proper opening/closing tension.

Interlink Adjusment

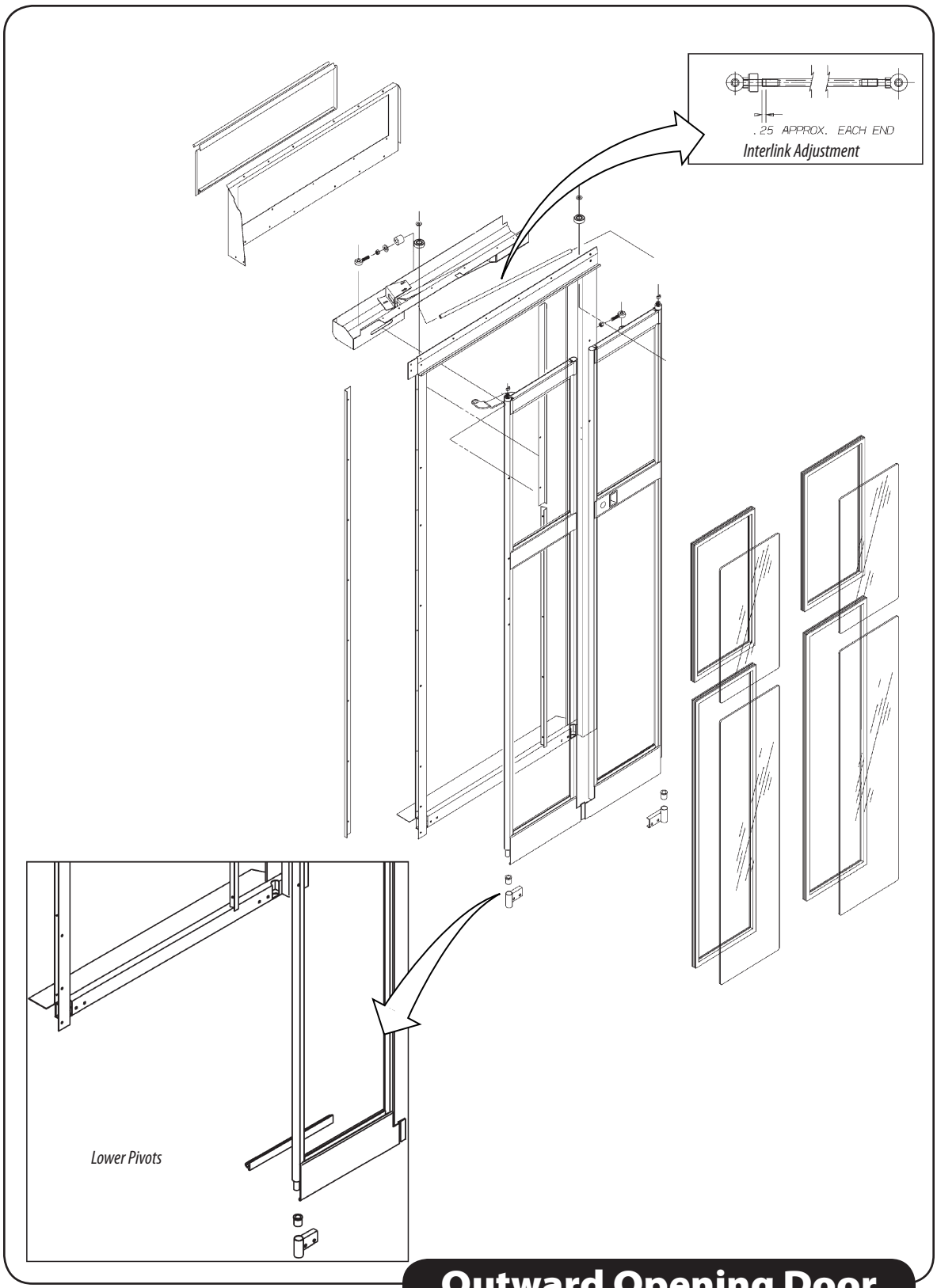
The mechanical link between the doors (the interlink rod) should be adjusted so that the rearward door closes and seats first. One of the spherical bearing, rod end connectors has a right-hand thread; the other has a left-hand thread. This allows for length adjustment by simply turning the interlink rod. The forward door panel then closes with an overlap to the rear of the bus, helping to reduce the intrusion of outside air while the bus is in motion. The forward door pivots across the centerline of a cam, thus locking the rear door panel in position.

When properly adjusted, the door should begin to require more energy to close as the trailing edge of the front door panel gets to within 2 or 3 inches of the closed position. When the mechanism is properly adjusted, you should only be able to push the door open by pressing on the forward door panel from the inside. The rearward panel should be locked into position and will not move until the forward panel moves.

1. With the doors open, loosen the jam nut at the forward end of the interlink rod. The jam nut on the rearward end of the interlink assembly is to hold the bumper in position and is located inside the access panel over the door.

2. Turn the interlink tube until, by trial and error, the door mechanism operates properly.

3. Tighten the jam nut securely.



Outward Opening Door

Manual Door Control

Manual Door Control Arm Removal

The manual door control rod does not need to be removed to adjust or remove the door panel assemblies. However, the clevis pin must be removed when removing the door panels.

1. Remove the cotter pin and clevis pin securing the control arm to the door.

2. If the control arm is in the way of your work, remove it by removing the pivot bolt, nut, and spacer from the handle.

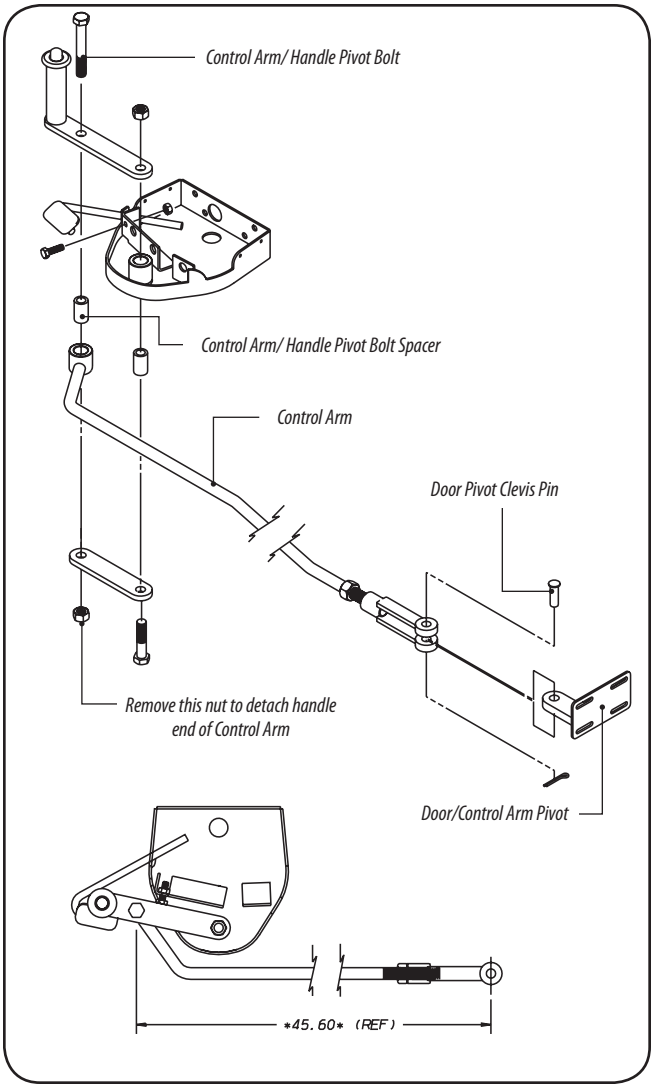
Manual Door Control Reinstallation

If the length of the manual control rod assembly is moved, the nominal length for outward opening doors should be set to 45.60 inches (115.82 cm). Then adjust to close with proper tension. When the door operates satisfactorily, tighten all hardware securely.

1. If necessary, install the door/control arm pivot. Snug up so it will not move. Do not tighten securely at this time.

2. With the doors in the closed position, pre-assemble the control arm to the approximate length required.

3. Attach the clevis to the door pivot and insert the clevis pin. Do not install the cotter pin at this time.



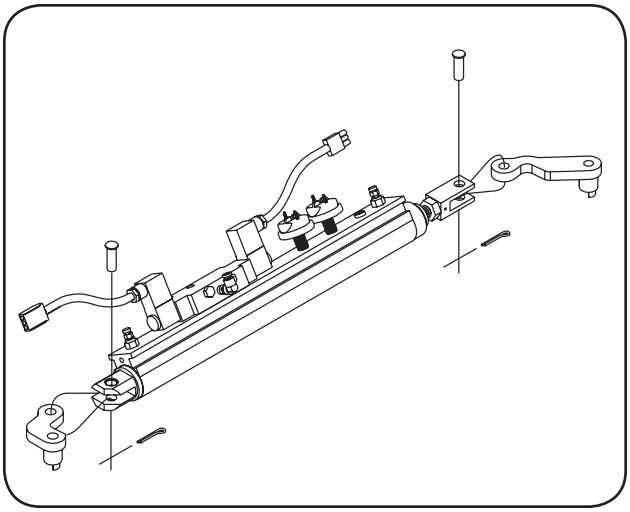
4. Assemble the opposite end of the control arm to the handle and tighten the locknut securely.

7. By trial and error, adjust the length of the rod assembly by removing the clevis pin and turning the clevis. Adjust the rod assembly length so that the control assembly handle passes through the center of the control assembly's cam action as the doors reach the fully open position.

8. When the door opening mechanism operates properly, tighten all hardware securely. Install the cotter pin into the clevis pin. Tighten the jam nut at the clevis in the rod assembly.

Pneumatic Door Opener

The pneumatically operated outward opening door operates similarly to the manual door described above but uses an air cylinder mechanism located inside the door header to actuate the door.



Pneumatic Door Opener Removal

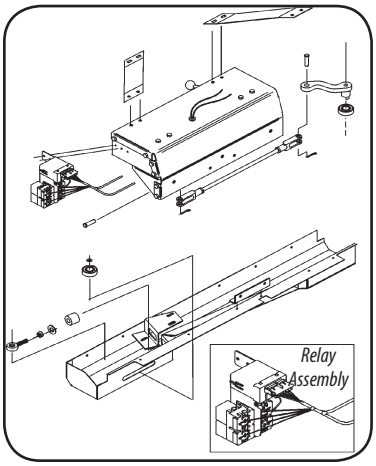
1. Remove the cotter pins and clevis pins from each end of the actuator.
2. Disconnect the electrical connectors.
3. Remove the pneumatic tubing. Identify the tubing as you remove it and replace it in the same positions.
4. Carefully remove the actuator from the compartment.

Pneumatic Door Opener Reinstallation

Installation of the pneumatic door actuator is accomplished in the reverse order of the removal instructions, above.

An air flow control valve located at each end of the actuator assembly allows adjustment of the speed of the door operation. Properly operating doors should cycle open or close in 3 seconds. If the doors do not operate properly, refer to "Adjustment of Outward Opening Door Mechanism", above.

Electric Door Opener



Electric Door Opener Removal

1. Remove hardware holding access panel over the door assembly.
2. Remove the nut and capscrew assembly from 10 places.
3. Disconnect electrical connectors at the relay assembly.
4. Remove the clevis pin from forward door lever.
5. Remove the clevis pin from rearward door lever.
6. Remove the actuator assembly.

Electric Door Opener Reinstallation

Install the electrically operated door actuator in the reverse order of the removal instructions above.

1. Pre-install the relay assembly on the actuator housing.
2. Preset the length of the actuator rod assembly to 18.50 inches (46.99 cm). Be sure the clevis pinholes are properly oriented.
3. Install the actuator assembly by installing bolt and locknut in 10 places. Tighten securely.
4. Install the actuator rod assembly clevis to the lever on the electrically operated actuator.
5. Install the actuator rod clevis to the forward door operating lever.
6. Check for proper operation of the actuator. It may be necessary to adjust the length of the actuator rod assembly so the door will stop before the motor crosses center.
7. If necessary, install the emergency release lever.
8. Move the open position stop to its rearmost position to prevent the motor driven actuator from rotating too far rearward.
9. After adjusting for proper operation, position cam on the rotating shaft to operate limit switch when the door is in the open position.

Door Panels

Door Panels Removal

If so equipped, optional safety equipment attached to the door panel's assembly must be disconnected and/or removed before continuing. Access to the door mechanism is provided over the door opening, inside the bus.

1. Remove the access panel cover or header.
2. If equipped with pneumatic door actuator, refer to Removal of Optional Pneumatic Door Opener above.
3. If equipped with electrically operated door actuator, disconnect the actuator rod clevis from the front door operating lever.
4. Remove Allen head machine screws and lock nuts from spherical bearing (at each end of the connector link).
5. Remove the connecting link.
6. Remove the nut, lock washer and flat washer from the bearing at the top outside corners of the door panels.
7. Support the door panels and remove two carriage bolts from the lower outside corner of each door panel.
8. Lift the door panel and slide the bottom, with bracket and bronze bushing attached, away from the stepwell. Some manipulation of the rearward door panel may be necessary to remove the door lever from the header.
9. Lower the door panel until it clears the header.
10. Set the door panel aside and remove the forward door panel in the same manner.
11. Remove the sealed ball bearings from the outside corners of the door header.
12. Remove the flanged bronze bearing and bracket from the bottom of each door panel.

Door Panels Reinstallation

Installation of the outward opening door panels is accomplished, in the reverse order of the removal instructions above.

1. Install the sealed ball bearings at two places in the header, at the outside corners.

2. Install the bronze bearings and brackets at the bottom outside corner of each door panel.

3. Install the rearmost door panel first. Some manipulation may be necessary to install the rear door panel control lever into the header.

4. Support the door panel and install the lower door pivot bracket and bronze bearing.

5. Install two carriage bolts to secure the pivot assembly in the stepwell.

6. Install the upper spacer.

7. Install the upper pivot through the upper support bearing. Install flat washer. Wipe pivot threads clean and coat the bottom 3 to 5 threads with Loctite™. Install lock washer and nut to hang door panel in frame. Torque to 30 ft-lbs (3.38 Nm).

8. Install forward door panel bronze bearing and bottom pivot bracket onto the door panel.

13. Install the upper pivot through the sealed ball bearing.

14. Lift and support the door panel while installing two carriage bolts to secure the bottom pivot to the stepwell. Install the flat washer. Wipe top pivot threads clean and apply Loctite™ to the bottom 3 to 5 threads. Install lock washer and nut. Torque to 30 ft-lbs (3.38 Nm).

Door Panel Glass Replacemement

With the old glass and the rubber gasket removed, clean the inside edges of the door panel opening. Using a new rubber gasket of the proper size:

1. Install a new rubber gasket onto the new glass.

2. Place a sash cord, or other suitable string, around the outside groove of the glass assembly.

3. Pull the string tight to make sure it seats fully into the groove. Leave the ends of the sash cord hanging down from bottom corners of new glass assembly. Do not lubricate the new gasket material.

4. Install the glass assembly into the door panel, from the inside, placing the bottom groove of the rubber gasket properly straddling the bottom of the opening in the door panel. Be sure the ends of the sash cord are on the outside of the door panel, protruding from the lower corners of the opening.

5. From the inside of the door assembly, press and hold the glass assembly securely into the hole.

6. From the outside of the door assembly, carefully pull the sash cord, causing the outer edge of the gasket to pop into place.

Stop Arms

Federal Motor Vehicle Safety Standard 131 requires all school buses in the United States to be equipped with a Stop Arm. The specific requirements for the blade, lights, lettering and reflectivity of the Stop Arms vary from state to state. Blue Bird provides Stop Arms as kits to match requirements for each state from which the school bus was ordered. Stop arms are available as either electric or air-operated.

Usually, the Stop Arm is located on the left side of the bus, at the front under the driver's window. In some cases, there is another Stop Arm on the left, toward the rear of the bus.

The driver most commonly controls Stop Arms manually via a switch. Some states require that Stop Arms be operated in concert with the Warning Lights when the bus is preparing to stop. Some states allow the lights to be on while the Stop Arm is retracted. In such case, the electronic controls are wired into the lighting system, and operation is automatic when the driver activates the warning light switch. In these cases, the driver will be alerted by an audible signal.

Air Operated Stop Arm

For pneumatically operated (air pressure) Stop Arms, the electric control switch operates an air valve solenoid which controls the flow of air to operate the Stop Arm. The air-operated system is dependant on the air brake system for pressure to operate.

The air stop arm may require periodic air pressure adjustment. The air regulator is accessible from the electrical panel located under the driver's window at the outside of the bus. To adjust the air pressure, remove the wire retaining clip and pull downward on the red lock ring. Turn the knob counterclockwise to decrease the airflow, and then slowly increase the air pressure until the Stop Arm is fully extended. Push the red lock ring upward and install the wire retaining clip.

Electric Stop Arm

Stop Arms may also be electrically operated. There may be a discrete switch for the driver, or the system may be wired into the warning light circuit.

Stop Arm Maintenance

Monthly, lubricate the breakaway hinge at the four pivot points using a high performance penetrating lubricant such as Triflow™ with Teflon.™ Ensure that the Stop Arm moves freely. Check all the fasteners for security and tighten as necessary. Quarterly, remove the covers (both front and rear) to inspect the security of the internal fasteners. Tighten as necessary.

Overview

The seating in your Blue Bird All American bus is designed for your safety and comfort. The placement and installation of school bus passenger seats is governed by federal regulations. The bus seating meets or exceeds FMVSS222 School Bus Passenger Seating and Crash Protection.

WARNING ***Do not attempt to modify the location of the passenger seats in your Blue Bird All American without reading the FMVSS222 specifications.***

Driver's Seat

Driver's Seat Adjustment

WARNING ***Do not attempt to adjust the driver's seat while vehicle is in motion. A sudden, unexpected adjustment to the driver's seat while vehicle is in motion could result in serious injury or death.***

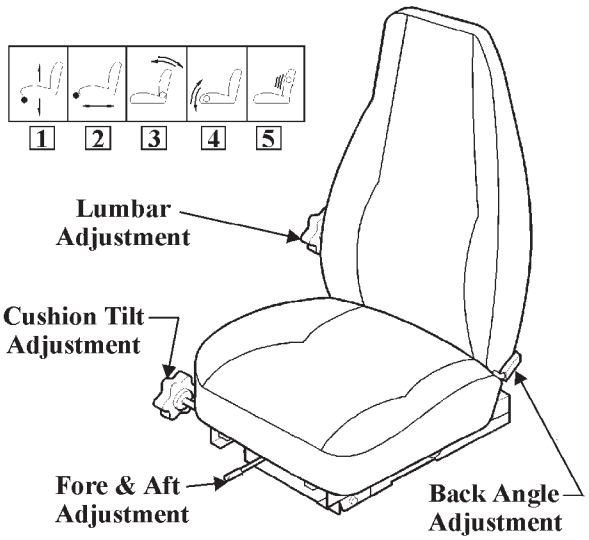
Weight and Height Adjustment. To adjust, push valve knob in to raise seat and pull out to lower seat. When properly adjusted, the seat should neither top nor bottom against the end limits of the vertical travel, under normal driving conditions. Adjustment position should also provide for driving visibility and vehicle control.

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

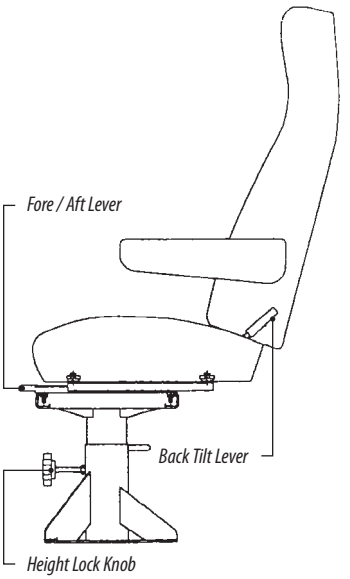
Back Angle Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle rearward to adjust to any position within the seat's range.

Cushion Tilt Adjustment. Rotate seat tilt knob to decrease or to increase seat tilt.

Lumbar Adjustment. Rotate knob forward to increase or rearward to decrease the support in the lumbar area.



Manually Operated Driver's Seat



Manually Operated Driver's Seat Adjustment

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

Height Adjustment. Loosen height lock knob in front. Lift height adjust handle on side. Slowly sit or stand to position seat at desired height. Release height adjust handle before applying full weight. Tighten handle in front. Fasten and adjust seat belt.

Back Tilt Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle rearward to adjust to any position within the seat's range.

Driver's Seat Lubrication

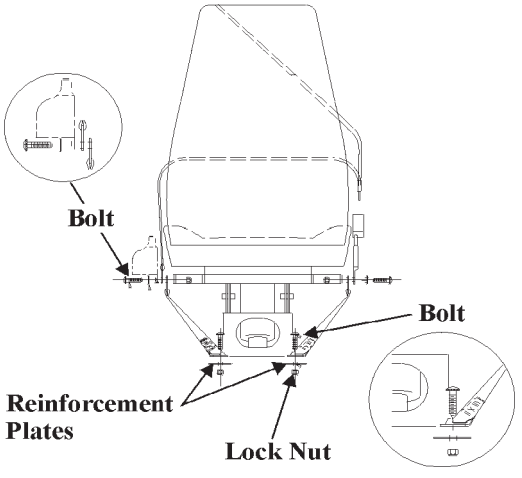
CAUTION ***Lubricants can damage vinyl. Use caution around upholstery.***
The moving parts of the driver's seat require occasional lubrication for ease of operation, and longevity of the seat. White lithium-based grease in an aerosol can is recommended. Motor oil 10W30 or 10W40 will provide adequate lubrication, although it may not be as easy to apply.

Driver's Seat Removal

1. Remove two (2) bolts and washers from seat belt tether assembly, if equipped. See Figure 3—Driver's Seat Attachment Points.
2. Remove six (6) bolts from seat base mount and floor.

Driver's Seat Reinstallation

1. Clean the six (6) bolts, removing dirt and grease.
2. Apply Loctite™ 242 Blue to five or six threads.
3. Install six (6) bolts and washers into the driver's seat mount.
4. Torque the six (6) bolts 15 to 20 foot-pounds.



Driver's Seat Belt Tether Installation (Air Seat Only)

1. Install two (2) washers and two (2) bolts.
2. Hand-tighten two (2) bolts.

CAUTION ***If washers are not installed, belt will not function as designed.***

Seat Care and Cleaning Tips

Dirt and Soil. Most dirt and soil may be removed with soap and warm water solution. If a stain is persistent, a stiff bristle brush may be used. Fabric covered seats should be rinsed with clean water after stain is removed.

Paint, Tar and Asphalt. Paint, tar and asphalt stains may become permanent if not cleaned immediately. Remove stain immediately, using a damp cloth and kerosene. Rub the stain gently, using small strokes.

Nail Polish and Lacquer-based Stains. Immediately soak up as much as possible with a dry cloth. Any remaining stain may be removed with a non-flammable cleaning fluid, such as Tuff Stuff™ or Ar-morall™ cleanser. Rinse thoroughly with clean water.

Gum, Grease and Shoe Polish. Immediately remove as much as possible. Shoe polish can permanently stain, if left unattended for a long period. Clean any remaining stain with a Tuff Stuff™ or Armorall™ cleanser.

Ink. Immediately remove stain using a damp cloth and alcohol.

Passenger DOT Seats

Blue Bird seats are built to meet Federal Motor Vehicle Safety Standards. School bus seats are equipped with a special foam back pad. When the pad is damaged, replace with an approved replacement part.

Passenger DOT Seat Maintenance

- Inspect and retighten seat leg and wall side mounting bolts every 90 days.
- Inspect and retighten cushion attachments with a Phillips head screwdriver each week.
- Inspect upholstery for cuts and tears every 90 days. If torn, remove upholstery by removing the staples at the bottom front of seat back, or bottom of cushion.

WARNING ***If seat cushions are removed for maintenance, they must be re-installed using the following instructions. Failure to comply with these instructions could result in injury from unattached seat cushions in the event of an accident.***

Passenger DOT Seat Cushion Removal

1. Loosen (do not remove) the two front swivel type clamps at the front underside of the cushion, with a Phillips tip screwdriver.

2. Rotate the swivel clamps to clear the front retaining channel frame.

3. Lift the forward edge of seat cushion 2 to 3 inches and pull cushion forward to remove.

Passenger DOT Seat Cushion Reinstallation

1. Place the rear edge of cushion down on the base portion of the seat frame, lifting the forward edge 2 to 3 inches.

2. Slide the cushion to the rear edge to engage the positive type clamp into the rear-retaining channel.

3. Lower the forward edge to the frame, making sure the swivel clamps are inside the frame and the posi-tive type clamps are secure on the rear-retaining channel.

4. Rotate the swivel clamp to engage the forward retaining channel frame.

5. Tighten with a Phillips tip screwdriver until clamps no longer rotate.

Track Mounted Passenger Seats

If your Blue Bird All American bus is equipped with track mounted passenger seats and you relocate a row of seats to accommodate wheelchairs, you must observe rules of spacing and placement. See FMVSS222 School Bus Passenger Seating and Crash Protection.

Track-Mounted Passenger Seat Removal

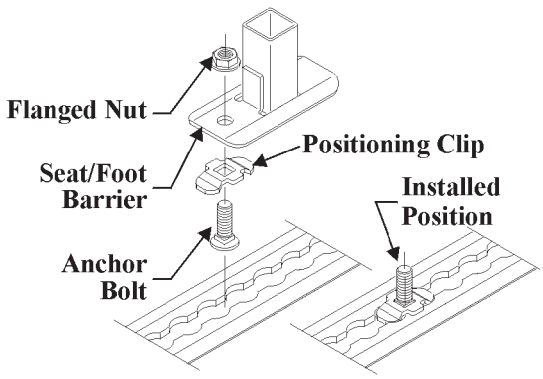
1. Remove flange nut from the anchor bolt at the seat/barrier foot.

2. Lift seat frame up and off of the anchor bolt.

Track-Mounted Passenger Seat Reinstallation

1. Set seat/barrier down on the anchor bolt and positioning clip.

2. Torque flange nut 34 to 37 foot-pounds.



Seat Belts & Shoulder Harnesses

Seat Belt Inspection and Maintenance

The seat belts, buckles and their attachments must be inspected weekly basis to ensure proper condition, security and operation. If necessary, lubricate seat belt buckles with a graphite lubricant. If a seat belt buckle is found inoperable, replace immediately. If there are any defects in the webbing of the seat belt (i.e., torn or frayed), replace before use. Hand-wash seat belt webbing with warm water and a mild soap. Rinse thoroughly and dry in shaded area.

CAUTION ***Do not bleach or re-dye the seat belt webbing. Such processing may severely weaken the belt.***

Driver's Seat Belt Operation

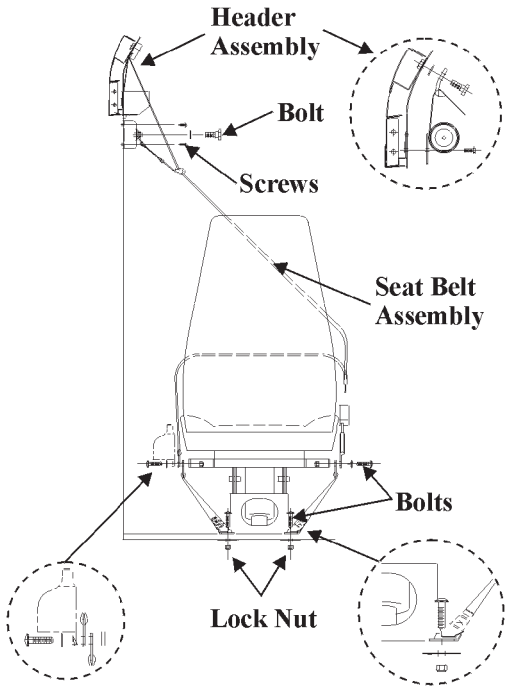
The driver's seat belt should be worn at all times when the vehicle is being driven. Blue Bird drivers' seat belts have automatic locking retractors and are self-adjusting. The seat belts also have an anti-cinch device to prevent the belt from tightening uncomfortably.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The driver's seat belt shoulder harness is an emergency locking belt. The harness may be either emergency locking or automatic locking, depending on the seat belt option chosen. The emergency locking retractor used for all shoulder harness, and specified lap belts, is dual sensitive, engaging when the vehicle tips 15 degrees or if the belt speed exceeds a preset rate.

Automatic locking retractors for specified lap belts are self-adjusting. Adjust the shoulder belt bracket upward for taller drivers downward for shorter drivers, or until maximum comfort is achieved.

To use, withdraw an ample length of seat belt from retractor(s) to allow engagement of buckle halves. Engage buckle halves and allow retractor to draw belt to a snub, comfortable fit. The seat can be released by pushing button in center of buckle.



Driver's Seat Belt Removal

1. Remove one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

2. Remove one (1) shoulder bolt and flat washer at the header assembly.

3. Remove two (2) screws at the header assembly.

4. Remove one (1) bolt from the mounting bracket. See Figure 5—Driver's Seat Belt Attach Points.

5.Remove two (2) bolts and washers from seat belt tether assembly. See Figure 5—Seat Belt Attach Points.

6. Remove one (1) lock nut, one (1) reinforcement plate and one (1) bolt from floor.

Driver's Seat Belt Reinstallation

1. Clean bolt, removing dirt and grease.

2. Apply Loctite™ 242 Blue to five (5) or six (6) threads.

3. Install one (1) bolt, one (1) reinforcement plate, lock nut and washer into floor.

4. Torque nut on bolt 15 to 20 foot-pounds.

5. Install two (2) bolts and washers at the rear of the driver's seat. See Figure 5—Driver's Seat Belt At-tach Points.

6. Install one (1) bolt at the mount bracket. See Fig-ure 5—Driver's Seat Belt Attach Points.

7. Install one (1) flat washer and one (1) shoulder bolt at the header assembly.

8. Install one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

9. Install two (2) screws at the header assembly.

Passenger Seat Belts

Individual lap belts for passengers are retractable or non-retractable, depending upon the option chosen. Insert the catch into the buckle, test for assurance of latch fit and pull loose end of strap until belt fits snugly across the lower hips, and not the waist.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The seat belt buckle can be released by pushing button in center of buckle. Turning the strap 90 degrees and pulling can move the adjustable end outward.

Passenger Seat Belt Removal

1. Remove ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side.

2. Remove one flange head screw from rear frame under seat on the aisle side and wall side.

Passenger Seat Belt Installation

1. Install one flange head screw to rear frame under seat on the aisle side and wall side.

2. Torque head screw 15 to 20 foot-pounds.

3. Install ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side. Screws are for the cover only, not the belt. Make sure they are in the plywood-tacking strip. Exposed screw points are not allowed inside back of seat.

Exterior Paint

The Blue Bird All American exterior is finished with a heat cured polyurethane. All exterior surfaces are smooth and free of wrinkles and dents. Exterior painted surfaces are properly prepared as required by the paint system supplier, prior to application of paint to assure a proper bond between the basic surface and successive coats of original paint for the service life of the bus. Drilled holes and cutouts in exterior surfaces are made prior to cleaning, priming and painting to prevent corrosion. The bus is completely painted prior to installation of exterior lights, mirrors and other items, which are applied to the exterior of the bus.

Paint is applied smoothly and evenly with the finished surface free of dirt and the following other imperfections:

A. Blisters or bubbles appearing in the topcoat film.
B. Chips, scratches, or gouges of the surface finish.
C. Cracks in the paint film.
D. Craters where paint failed to cover due to surface contamination.
E. Over spray.
F. Peeling
G. Runs or sags from excessive flow and failure to adhere uniformly to the surface.
H. Chemical stains and water spots.

To the degree consistent with industry standards for commercial vehicle finishes, painted surfaces have gloss and orange peel minimized. All exterior finished surfaces are impervious to diesel fuel, gasoline and commercial cleaning agents. Finished surfaces resist damage by controlled applications of commonly used graffiti-removing chemicals. Colors and paint schemes shall be specified by Procuring Agency.

Interior Paint

Materials are selected on the basis of maintenance, durability, appearance, safety, flammability, and tactile qualities. Trim and attachment details are kept simple and unobtrusive. Materials are strong enough to resist everyday abuse and vandalism; they are resistant to scratches and markings. Interior trim is secured to avoid resonant vibrations under normal operational conditions.

Front End

The entire front end of the bus is constructed to minimize debris accumulation behind the dash and to prevent the operator's feet from kicking or fouling wiring and other equipment. Paneling across the front of the bus and any trim around the operator's compartment is formed metal, plastic, or composite material. Plastic dash panels are reinforced, as necessary, and replaceable. All colored, painted, and plated parts forward of the passenger seat barriers are finished with a dull matte surface to reduce glare. Color is coordinated to compliment the entire interior of the bus.

Rear End

The rear interior surfaces are constructed with steel. Color is coordinated to compliment the entire interior of the bus.

Interior side trims and panels are steel and aluminum. Panels are tamper-resistant and reinforced, as necessary, to resist vandalism and other rigors of school bus service. Individual trim panels and parts are interchangeable to the extent practicable. Untrimmed areas are painted and finished. Color is coordinated to compliment the entire interior of the bus.

Headlining

Standard ceiling panels are constructed of steel material. Headlining is supported to prevent buckling, drumming, or flexing and is secured without loose edges. Moldings and trim are aluminum, or plastic, colored to complement the interior of the bus.

Fastening

Interior panels are attached so that there are no exposed unfinished or rough edges or rough surfaces. Panels and fasteners are not easily removable by passengers. Interior trim fasteners are rivets or cross-recessed head screws.

Floor Covering

The floor covering is a non-skid walking surface that remains effective in all weather conditions and complies with all ADA requirements. RCA rubber flooring is also an available option. The floor covering, as well as transitions to the entrance area, are smooth and present no tripping hazards. Color/pattern is consistent throughout the floor covering.

The floor in the operator's compartment is easily cleaned and arranged to minimize debris accumulation. The driver's platform is raised two inches above the floor in the passenger area to prevent objects from rolling or sliding forward and interfering with the driver's operation of the bus.

The floor under the seats is covered with smooth surface flooring material. The floor covering closely fits the sidewall cove.

Undercoating

The body is undercoated with "Tectyl 355" and baked for durability before being mounted on the chassis. This ensures the most effective protection from road salt and other rust causing agents. "Tectyl 355" undercoating meets a rigorous 1000 hour salt spray test.

Additional undercoating may be applied over the existing undercoat provided a commercial grade undercoating material is used. Additional undercoating may be desireable in areas where corrosive chemicals are used for snow and ice removal.

Lettering/Decals

The standard lettering on the Blue Bird All Amrican displays "SCHOOL BUS" in 8 inch black vinyl lettering on the front and rear roof caps. Additional lettering is available. Contact your Blue Bird Dealer for available features.

"3M" diamond grade reflective vinyl is used as a safety feature to make the bus more visible in adverse or low light conditions. Reflective vinyl frames the words "SCHOOL BUS" on the front and rear roof caps. A 2 inch wide strip at the floor line extends the full length of the body on both sides. The rear of the bus is framed at the top, bottom and both sides using a 1.75 inch reflective strip. A one inch strip is used around all emergency exits. When replacing the reflective vinyl, use only that which meets federal, state and local regulations for school buses.

School Bus Lettering

Reflective Tape

Exterior Cleaning

Before cleaning and waxing your bus a few basic rules should be followed:

- Start your project with the bus out of direct sunlight.
- Make sure the paint is not warm to the touch before applying any cleaning product or wax.
- Spray your bus with ample amounts of water before washing. Use the water to spray off dirt and other contaminates that will scratch the surface.
- Wash and rinse in sections so the wash soap doesn't dry before being rinsed off.
- Drying your bus after washing is necessary to prevent water spots – mineral deposits that etch the outline of a drop of water into your vehicle's paint.
- Read the manufacturer's directions on all products used prior to use.

Wash

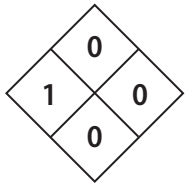
In order to preserve your vehicle's finish, Blue Bird requires protection of the finish by washing a minimum once every 3 months.

- Wash the vehicle in lukewarm or cold water.
- Use a lamb's-wool or paint-safe microfiber washing mitt to prevent scratching the surface.
- Do not use hot water or wash in the direct rays of the sun.
- Do not use strong soap or chemical detergents.

Only cleaners with an HMIS rating of 1,0,0,0 or less should be used to clean the buses. This HMIS rating is available on all product MSDS.

Hazard Rating (NFPA/HMIS)

Health = 1 Reactivity = 0
Fire = 0 Special = 0



Rating Scale

0 = Minimum 1 = Slight
2 = Moderate 3 = Serious
4 = Severe

To wash units, Blue Bird Corporation recommends Bird Bath™ Bus Wash & Wax Concentrate, available from authorized Blue Bird Dealers. Bus Wash & Wax is a concentrated vehicle wash (rated triple-zero) that is recommended to be mixed at up to a 20/1 ratio for new and reconditioned buses.

CAUTION ***Pressure washing may cause damage to finish. Pre-test pressure washer on a similar surface before applying pressure and chemicals to your vehicle. Pressure washers that re-circulate should filter the water to remove abrasive grit.***

Magnesium chloride, calcium chloride and other salts, ice melting agents, road oil and tar, tree sap, bird droppings, chemicals from industrial chimneys, and other foreign matter may damage vehicle finishes if allowed to remain on painted surfaces. Prompt washing may not completely remove all of these deposits. Additional cleaners may be needed. When using chemical cleaners developed for this purpose, be certain they are safe for use on painted surfaces.

Wax

Wax your bus a minimum of once a year with a nonabrasive wax. This is required to remove accumulated residue and eliminate any weathered appearance. It is essential that units are not waxed in direct sunlight.

Products labeled cleaner wax or polish should not be used as they are somewhat abrasive and can actually remove some paint from the surface of the vehicle. Care should be taken when choosing a wax to make sure that it does not contain abrasive materials i.e.; calcium carbonate, pumice, plastic beads, etc.

- Before waxing, thoroughly wash and dry the bus.
- Never wash or wax a bus in direct sunlight or if the paint is hot to the touch. The sun can soften the paint and make it more susceptible to scratching.
- Use a lamb's-wool mitt for washing and soft cotton rags or microfiber towels for waxing. Do not use rags for waxing; they can trap dirt and scratch the finish. Synthetic fabrics and brushes can also scratch the finish.
- Wash and wax in small sections. This saves time and if the wax stays on too long, it can be difficult to remove.

Approved Waxes

- Mequiars Gold Class Liquid Wax
- Mequiars NXT Generation® Tech Wax® 2.0 Paste or Liquid
- Black Magic Wet Shine Liquid Wax
- Turtle Wax Carnauba Car Wax T-6
- Turtle Wax 1 Step Wax & Dry T-9
- Nu Finish NFP-80

Bus Downtime Treatment

During periods of bus downtime, Blue Bird Corporation recommends the application of Bird Bath™ Bus Guard Protectant available from Blue Bird authorized dealers to protect exterior surfaces. Bus Guard is a triple-zero product that, when properly applied, protects against harmful UV rays and other damaging environmental conditions. For sufficient protection, see product instructions for the proper application requirement.

Owners should refer to the limited warranty statement supplied with the vehicle regarding their responsibilities for care and maintenance of the vehicle during the warranty period.

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PUBLICATION NUMBER 10026187

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